Project:	**00RT8098**
File:	**MC1072**
Report:	**000236**
Date:	**June 19, 2000**
Model:	**WM1026A** **FCC ID: OL7WM-1026A**

Test Report

On

Electromagnetic Compatibility Testing

Peracom, Inc.

Cary, NC USA

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Test Report Details:

Tests Performed By:	**Underwriters Laboratories Inc.** **12 Laboratory Drive** **Research Triangle Park, NC 27709**
Tests Performed For:	**Peracom, Inc.** **13000 Weston Parkway Suite 105** **Cary, NC 27513 USA**
Applicant Contact:	**Mr. Ralph Yeager** **Engineer** **Voice: (919) 379-2763**
Test Report Number:	**000236**
Test Report Date:	**June 19, 2000 (Revised August 11, 2000)**
Product Type:	**Wireless Keyboard**
Model Number:	**WM1026A**
Sample Serial Number:	**Pre-production manufactured sample**
Sample Tag Number:	**S00LB275B**
EUT Category:	**Transmitter**
EUT Type:	**Table Top**
Sample Receive Date:	**June 14, 2000**
Testing Start Date:	**June 14, 2000**
Date Testing Complete:	**June 17, 2000**

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Summary of Testing:

Test #	Test Name Test Requirement/Specification	Comply	Does Not Comply	See Remark
1	Radiated Disturbance Emissions - 9 kHz to 30 MHz 47 CFR Part 15, Subpart C / 47 CFR Part 15, Subpart C Section 15.209	X	-	1
2	Radiated Disturbance Emissions - 30 to 1000 MHz Electric Field 47 CFR Part 15, Subpart C / 47 CFR Part 15, Subpart C Sections 15.209 and 15.249	X	-	1
3	Radiated Disturbance Emissions - 1 to 10 GHz Electric Field 47 CFR Part 15, Subpart C / 47 CFR Part 15, Subpart C Sections 15.209 and 15.249	X	-	1
4	Radiated Disturbance Emissions - Occupied Bandwidth 47 CFR Part 15, Subpart C / 47 CFR Part 15, Subpart C Section 15.249	X	-	1
5	Radiated Disturbance Emissions - Peak-to-Average Ratio 47 CFR Part 15, Subpart C / 47 CFR Part 15, Subpart C Section 15.249	N/A	N/A	2
6	Radiated Disturbance Emissions - Restricted Bands of Operation 47 CFR Part 15, Subpart C / 47 CFR Part 15, Subpart C Section 15.205	X	-	

Remarks:

1) The EUT was found to **comply** with FCC Part 15 Section 15.249 rules for transmitters in 902-928 MHz band. For spurious emissions the EUT was found to **comply** with the general rules for low-powered transmitters in Section 15.209 and Restricted Bands in Section 15.205. Results can also be considered applicable to Canadian RSS-210 Issue 2, Rev.1 Section 6.2.2.

2) No limit applies. Result used to calculate average value from peak measurement for Tests 1 through 4.

3) Emissions Designator interpreted to be P0D341K per FCC Part 2.201.

Conclusion:

The tests listed in the Summary of Testing section of this report have been performed and the results recorded by Underwriters Laboratories Inc. in accordance with the procedures stated in each test requirement and specification. The test list was determined by the Applicant as being applicable to the Equipment Under Test. As a result, the subject product has been verified to comply or not comply as noted in the Summary of Testing with each test specification. The test results relate only to the items tested.

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Reviewed By:

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Test Facilities:

Test Location A) 10-Meter Anechoic Chamber (Industry Canada - IC 2953, NVLAP - 200246-0, VCCI - R-722)

Constructed by Lindgren RF Enclosures, this room consists of a 17.9 by 12 by 8.3 m (inside clearance) shielded room lined with TDK absorber material. The walls, floor (conducting ground plane) and ceiling are constructed of double sided galvanized sheet steel supported by 19 mm thick particle board. The interior walls and ceiling are covered with 10 by 10 cm, 4.6 mm thick ferrite tiles and partially covered with polystyrene absorber cones. Removable floor tiles and cones covering the floor between the EUT and antenna are provided when RF immunity testing is performed.

Room is provided with a 4.0 m diameter embedded turntable and a 1.2 by 2.1 m and 2.4 by 2.4 m double knife edge doors for access. Also, the room is fed electrical EUT power via permanently installed filters and is provided with a permanently mounted video surveillance camera. A remotely controllable antenna mast is located in the room for positioning the measuring antenna from 1 to 4 m above the ground plane.

Test Location B) Compact Anechoic Chamber

Constructed by Lindgren RF Enclosures, this room consists of a 6 by 3 by 2.9 m (inside clearance) shielded room lined with TDK absorber material. The walls, floor (conducting ground plane) and ceiling are constructed of double sided galvanized sheet steel supported by 19 mm thick particle board. The interior walls and ceiling are covered with 10 by 10 cm, 4.6 mm thick ferrite tiles and partially covered with polystyrene absorber cones. Removable floor tiles and cones covering the floor between the EUT and antenna are provided when RF immunity testing is performed.

Room is provided with a 1.5 m diameter embedded turntable and a 1.2 by 2.1 m double knife edge door for access. Also, the room is fed electrical EUT power via permanently installed filters and is provided with a permanently mounted video surveillance camera.

Test Location C) RF Shielded Room (VCCI - C-744, NVLAP - 200246-0)

Constructed by Lindgren RF Enclosures, this room consists of a 7.3 by 4.3 by 2.7 m (inside clearance) shielded room. The walls, floor (conducting ground plane) and ceiling are constructed of double sided galvanized sheet steel supported by 19 mm thick particle board. Room is provided with a 1.2 by 2.1m double knife edge door for access. Also, the room is fed electrical EUT power via permanently installed filters and is provided with a portable video surveillance camera.

Test Location D) Ground Reference Plane # 1 (VCCI - C-742, NVLAP - 200246-0)

Horizontal floor ground reference plane constructed of double sided galvanized sheet steel supported by 19 mm particle board and measures 3.6 by 3.0 m. Located next to one vertical wall of the Control Room and is, therefore, provided with a 3.0 by 3.6 m vertical ground reference plane constructed of the same material. The horizontal and vertical planes are continuously bonded along their entire length. Power filters and LISNs, when required, are placed on top of and bonded to the horizontal floor ground reference plane.

Test Location E) Ground Reference Plane # 2 (VCCI - C-743, NVLAP - 200246-0)

Horizontal floor ground reference plane constructed of double sided galvanized sheet steel supported by 19 mm particle board and measures 4.3 by 5.2 m. Located next to one vertical wall of the RFD Shielded Room and is, therefore, provided with a 4.3 by 2.8 m vertical ground reference plane constructed of the same material. The horizontal and vertical planes are continuously bonded along their entire length. Power filters and LISNs, when required, are placed on top of and bonded to the horizontal floor ground reference plane.

Test Location F) Ground Reference Plane # 3

Horizontal floor ground reference plane constructed of double sided galvanized sheet steel supported by 19 mm particle board and measures 3.6 by 3.6 m. Power filters and LISNs, when required, are placed on top of and bonded to the horizontal floor ground reference plane.

Test location G) Magnetic Field Ground Reference Plane

Horizontal floor ground reference plane constructed of 1.5 mm thick aluminum measuring 3.6 by 2.4 m.

Test Location H) Outdoor Ground Reference Plane

Horizontal floor ground reference plane constructed of 1.5 mm thick aluminum measuring 3.6 by 3 m and located next to the outside wall of the EMC lab rear entrance.

Test Location I) Harmonic Current Test Area

Located on Lab floor in front of Standard Source Impedance Power Supply.

Test Location X) Other

If needed, as described in the Comments Section of Test Results.

EUT Information:

Equipment Used During Test:

Use*	Product Type	Manufacturer	Model	Comments
EUT	Wireless Keyboard	Peracom, Inc.	WM-1026A	

* Use = EUT - Equipment Under Test, ACC - Accessory (Not Subjected to Test), or SIM - Simulator (Not Subjected to Test)

Input/Output Ports:

Port #	Name	Type*	Cable Max. >3m	Cable Shielded	Comments
0	Enclosure	N/E	No	No	

* AC = AC Power Port DC = DC Power Port N/E = Non-Electrical
I/O = Signal Input or Output Port (Not Involved in Process Control)
PMC = Process Measurement and Control Port

EUT Internal Operating Frequencies:

Frequency (MHz)*	Description
916.3 to 916.7	Keyboard RF operating frequency (tolerance range)
4.000	Microprocessor Clock

* List all frequencies intentionally generated in the product above 9kHz.

Power Interface:

Mode #	Voltage (V)	Current (A)	Power (W)	Frequency (DC/AC-Hz)	Phases (#)	Comments
Rated	4.5	-	-	DC	1	
1	4.5	-	-	DC	1	Internally regulated to 3.3 volts

EUT Operation Modes:

Mode #	Description
1	Keyboard contains special Flash program in microprocessor to continuously send keystrokes when battery is installed. This was done to eliminate the need to depress keys during testing.

EUT Configuration Modes:

Mode #	Description
1	EUT keyboard is alone on tabletop. Three fresh 1.5V “AA” batteries were installed prior to test.

EUT Construction Information:

1) EUT operates at a fixed frequency of 916.5 Mhz as designed using a crystal. The crystal has a frequency tolerance of +/- 200 kHz. The frequency is not tunable.

2) EUT is fully self-contained and does not require nor provides connectors for attachment of any peripheral equipment.

3) EUT contains a fixed, integrated antenna inside the plastic enclosure. The antenna cannot be easily removed or replaced.

Information for Authorization:

1) EUT is **not** requesting authorization under transition provisions as detailed in Section 15.37.

Test 1: Radiated Disturbance Emissions - 9 kHz to 30 MHz

Test Requirement: 47 CFR Part 15 Subpart C

Test Specification: 47 CFR Part 15 Subpart C Section 15.209

Test Procedure:

The test was performed in accordance with the Test Requirement and Specification and configured as noted in the Test Setup. The EUT was placed inside the anechoic chamber and connected to the proper power supply source. A peak measurement was first made by scanning the entire test frequency range and maximizing the EUT emissions by rotating the EUT. Then, a measurement was taken for all peak emissions to verify each were below the Test Limits. In each case, all cables and equipment were adjusted and EUT orientation were varied for maximum emissions.

Per FCC instructions at TCB training seminar (Heirman, Feb 2000) these measurements shall be made with a loop antenna and converted to electric field limits using the impedence of free space (377 ohms, or 51.5 dB). Measurements made at less than the specified measurement distance (for ranges below 30 Mhz) are adjusted assuming 40 dB/decade as per FCC Part 15 rules.

Test Details:

Section 15.209 Radiated Disturbance Limits, General Requirements, for Subpart C Equipment at a measuring distance of 3m*.

Frequency Range MHz	Quasi-Peak or Average Limits** µV/m	Quasi-Peak or Average Limits** dBµV/m	Quasi-Peak or Average Limits** µA/m	Quasi-Peak or Average Limits** dBµA/m
0.009 to 0.490*	24,000/F (F in MHz)	20*log(24,000/F)	24,000/(F*377)	20*log(24,000/F) - 51.5
0.490 to 1.705*	2400/F (F in Mhz)	20*log(2400/F)	2400/(F*377)	20*log(2400/F) - 51.5
1.705 to 30*	3000	69.5	8.0	18.0
30 to 88	100	40	N/A	N/A
88 to 216	150	43.5	N/A	N/A
216 to 960	200	46	N/A	N/A
Above 960***	500	54	N/A	N/A

* Measurement distances of 300 or 30 meters adjusted to 3 meters by $1/r^2$.
** Measurement using Quasi-peak detector except an Average Detector for 9-90 kHz, 110-490 kHz, and above 1000 MHz
*** Peak Limit 20 dB above Average Limit per Section 15.35

Test Deviations:

None

Test Setup: Only the following ports were tested. See EUT Information for details.

Test Item	Port #	Port Name	EUT Operation Mode	EUT Configuration	Power Interface
A	0	Enclosure	1	1	1

Test 1 - Results: Radiated Disturbance Emissions - 9 kHz to 30 MHz Electric Field

Test Results Summary:

Test Item	Test Location	Humidity (%)	Temperature (ºC)	Pressure (kPa)	Pass/Fail (P/F)	Date Completed	Comment #
A	A	55	22.5	100.1	P	6/17/00	

The EUT was considered to **Pass** the Requirements.

Comments:

Comment #	Description

Test 1 - Test Equipment Used: Radiated Disturbance Emissions - 9 kHz to 30 MHz Electric Field

Equipment ID	Description	Manufacturer	Model Number	Last Cal.	Next Cal.
AT0006	Loop Antenna, 10 kHz to 30 MHz	Electro-Metrics	EM-6879	10/27/99	10/31/00
ATA034	52ft Cable, N - N	UL	HELIAX	8/28/99	8/31/00
ATA038	33ft Cable, N - N	EMC Technologist	RG-214	7/30/99	7/31/00
ATA078	1.5m Cable, N - N	Micro-Coax	Low Loss Coaxial	11/2/99	11/30/00
HI0034	Temp/Humid. Indicator	Cole - Palmer	99760-00	12/20/99	12/31/00
SAR001	EMI Receiver	Hewlett Packard	8572A	12/14/99	12/31/00

The above equipment has been calibrated and is within the manufacturer's published limit of error. Calibration is traceable to the National Institute of Standards & Technology(NIST) and conforms to ANSI/NCSL Z540-1-1994.

Test 1, Item A - Discrete Data: Radiated Disturbance Emissions - 9 kHz to 30 MHz Electric Field

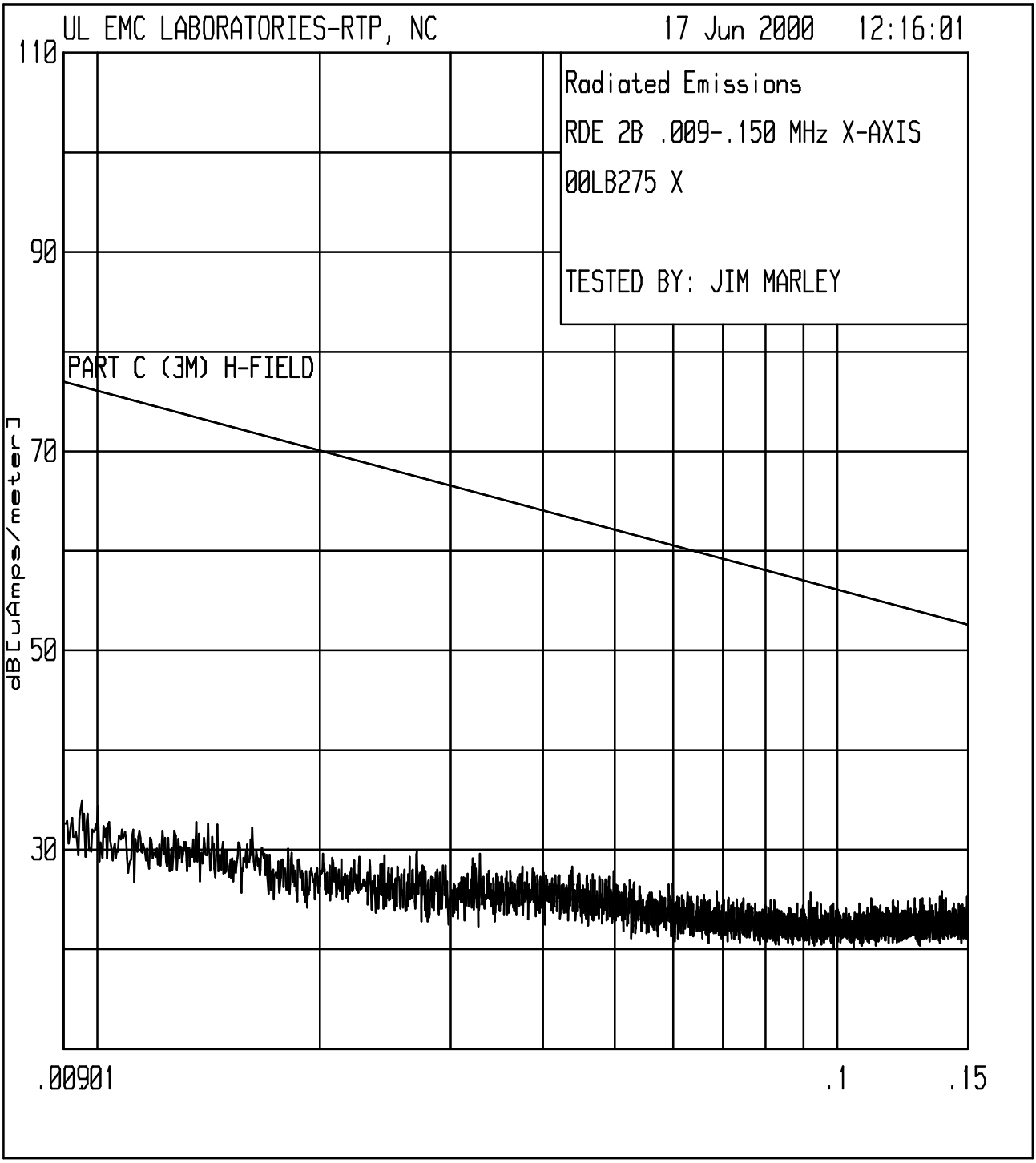
Test Item (A-Z)	Detector Type* (P/Q/A)	Antenna Polarity (H/V)	Antenna Distance (m)	Measured Frequency (MHz)	Measured Value (dBµV)	Equipment Correction (dBA/m/V)	Corrected Value (dBµA/m)	Corrected Limit** (dBµA/m)	Spec Margin (dB)	Comments *** (#)
A	P	X	3	0.0095	25.4	9.5	34.9	76.5	-41.6	
A	P	X	3	0.0162	25.4	6.8	32.2	71.9	-39.7	
A	P	X	3	0.0438	23.1	5.2	28.3	63.3	-35.0	
A	P	X	3	0.1384	19.2	6.6	25.8	53.3	-27.5	
A	P	X	3	0.1537	-2.5	2.7	0.2	52.4	-52.2	
A	P	X	3	0.6428	-3.0	-8.2	-11.2	19.9	-31.1	
A	P	Y	3	0.0090	24.3	10.5	34.8	77.0	-42.2	
A	P	Y	3	0.0194	25.0	5.8	30.8	70.3	-39.5	
A	P	Y	3	0.0418	24.1	5.2	29.3	63.7	-34.4	
A	P	Y	3	0.1342	18.4	6.5	24.9	53.8	-28.9	
A	P	Y	3	1.3556	-1.4	-11.3	-12.7	13.5	-26.2	
A	P	Y	3	27.0755	-3.1	-11.6	-14.7	18.0	-32.7	
A	P	Z	3	0.0096	25.6	9.5	35.1	76.5	-41.4	
A	P	Z	3	0.0402	24.6	5.3	29.9	64.0	-34.1	
A	P	Z	3	0.1327	19.4	6.5	25.9	53.6	-27.7	
A	P	Z	3	0.8859	-3.2	-10.1	-13.3	17.2	-30.5	
A	P	Z	3	4.5607	-1.7	-13.5	-15.2	18.0	-33.2	
A	P	Z	3	29.1604	-2.8	-11.5	-14.3	18.0	-32.3	

Notes: * P = Peak, Q = Quasi-Peak, A = Average.
** Limit adjusted to 3 meters by 40 dB/decade (80 dB for 9 kHz to 490 kHz, and 40 dB for 490 kHz to 30 MHz). Specified Electric Field limit converted to Magnetic Field using 377 Ω (or 51.5 dBΩ)

Sample Calculation: Corrected Value = Measured Value + Equipment Correction(Cable Loss (dB) - Amplifier Gain (dB, if used))
Corrected $\text{Limit}_{dBuA/m}$ = Specified $\text{Limit}_{dBuV/m}$ + Distance Conversion - Impedence of Free Space.

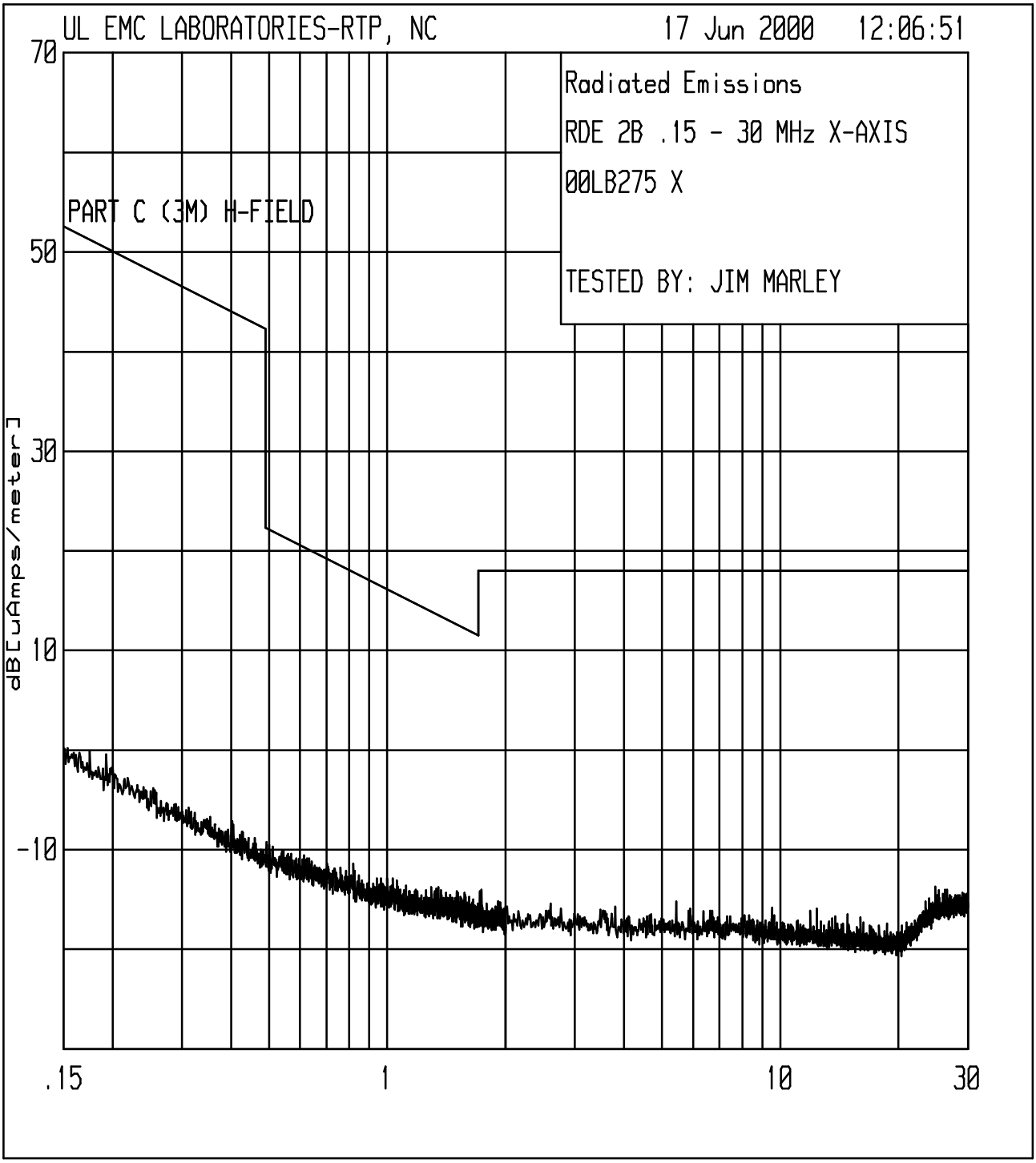
Test 1, Item A - Peak Plot:

Radiated Disturbance Emissions - 9 kHz to 150 kHz Electric Field X-axis



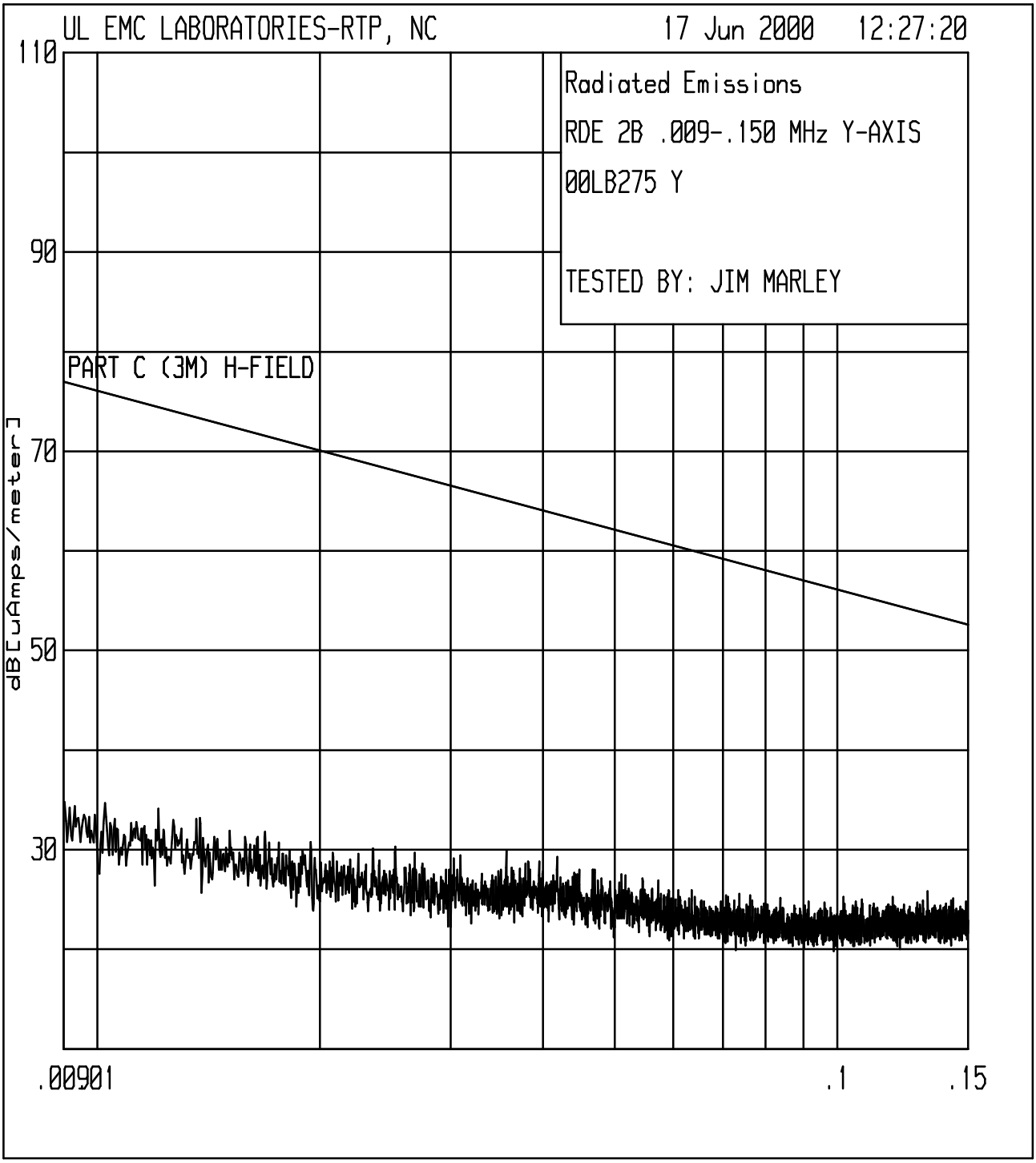
Test 1, Item A - Peak Plot:

Radiated Disturbance Emissions - 150 kHz to 30 MHz Electric Field X-axis



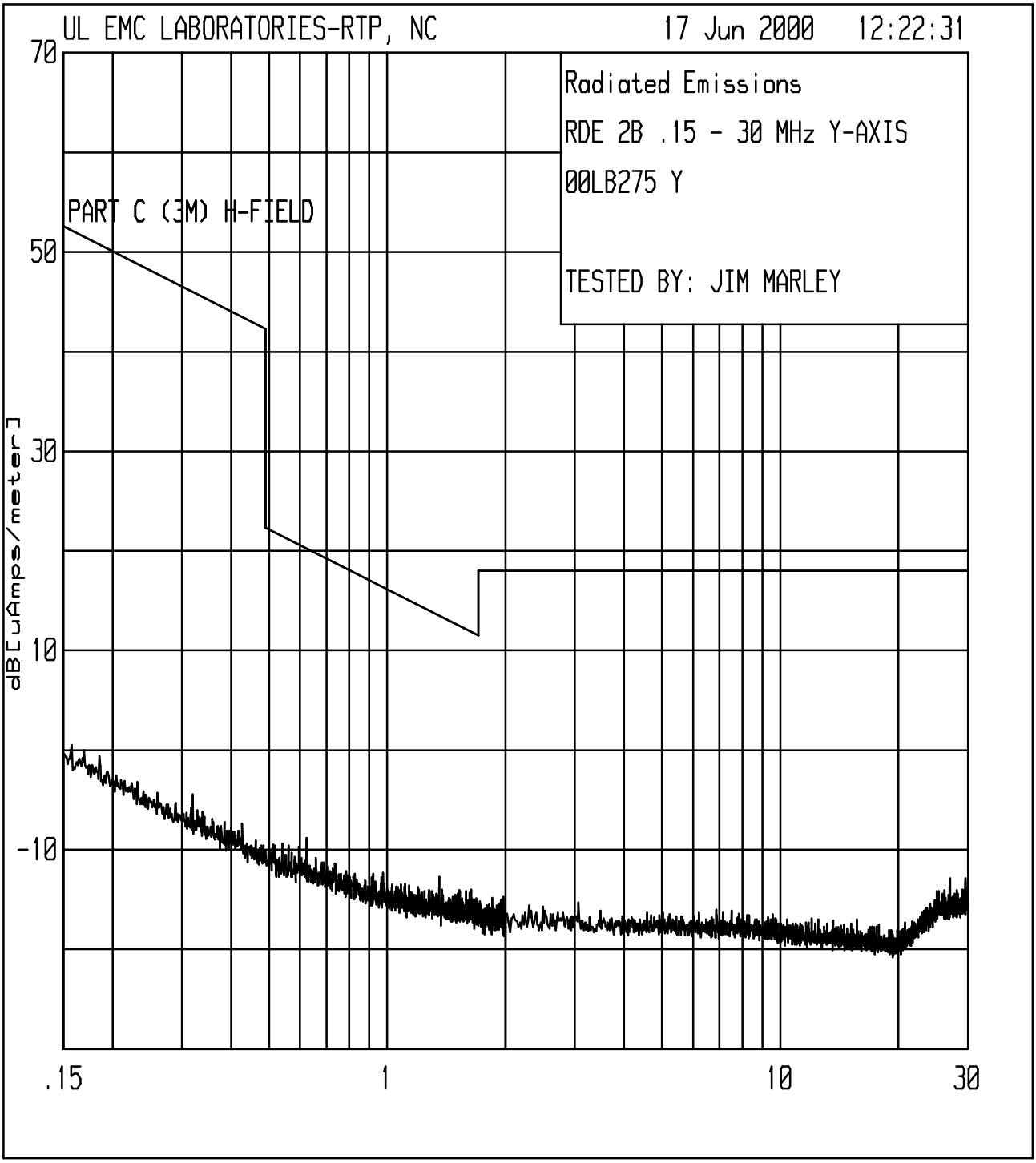
Test 1, Item A - Peak Plot:

Radiated Disturbance Emissions - 9 kHz to 150 kHz Electric Field Y-axis



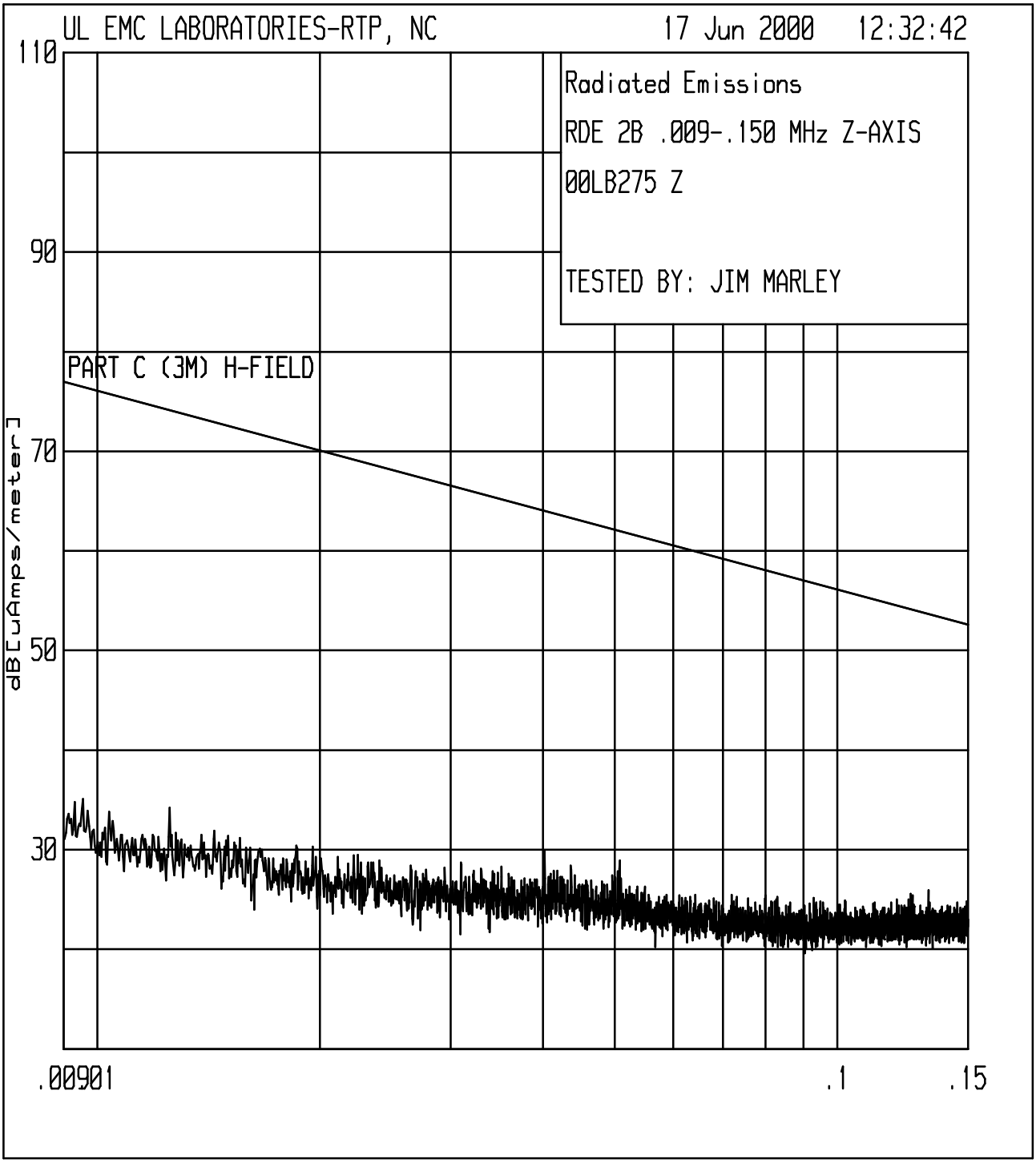
Test 1, Item A - Peak Plot:

Radiated Disturbance Emissions - 150 kHz to 30 MHz Electric Field Y-axis



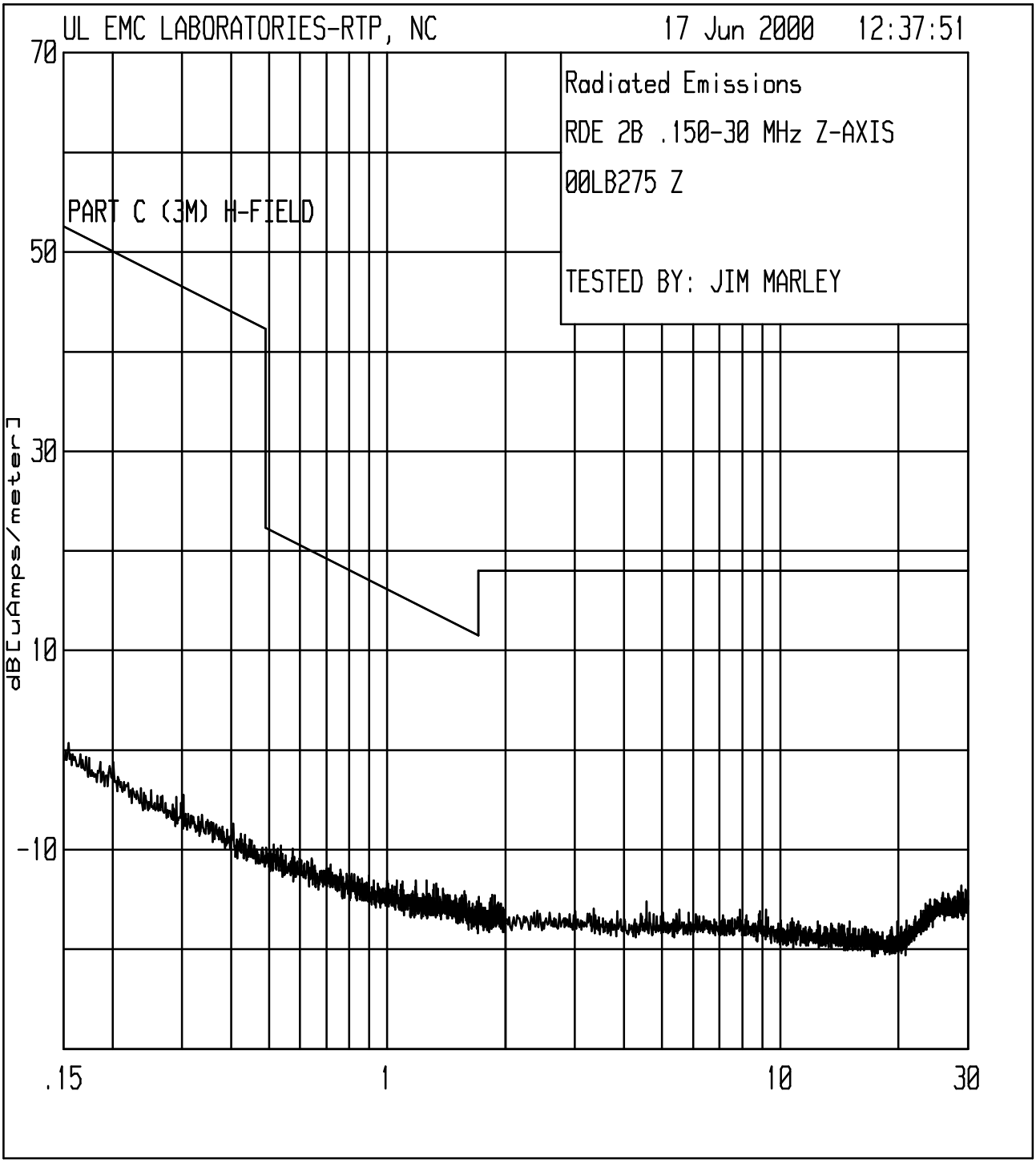
Test 1, Item A - Peak Plot:

Radiated Disturbance Emissions - 9 kHz to 150 kHz Electric Field Z-axis



Test 1, Item A - Peak Plot:

Radiated Disturbance Emissions - 150 kHz to 30 MHz Electric Field Z-axis



Test 1, Item A - Test Set-Up Photo: Radiated Disturbance Emissions - 9 kHz to 30 MHz Electric Field
(Test Set-Up photo representative of all test performed)

Test 2: Radiated Disturbance Emissions - 30 to 1000 MHz Electric Field

Test Requirement: 47 CFR Part 15, Subpart C

Test Specification: 47 CFR Part 15, Subpart C, Section 15.209

Test Procedure:

All testing was performed in UL's 10 meter semi-anechoic chamber. The chamber meets the FCC's site attenuation criteria for use as an alternative measurement site. The EUT was tested per ANSI C63.4:1992 test method placed on a non-conductive 1m x 1.5m table 80 cm above the ground plane. The receive antennas used were a biconical antenna from 30-300 MHz and a log-periodic antenna from 300-1000 MHz. The turntable was rotated from 0 to 360 to determine the worst-case emissions angle for each frequency. The antenna mast was raised and lowered between 1 and 4 meters above the ground plane to determine the worst-case antenna height. Both Vertical and Horizontal antenna polarities were investigated.

Section 15.209 Radiated Emissions Limit above 30 MHz - General Requirements

Frequency Range (MHz)	Field Strength (µV/m)	Field Strength (dBµV/m)	Measurement Distance (m)
30 to 88	100	40.0	3
88 to 216	150	43.5	3
216 to 960	200	46.0	3
above 960	500	54.0	3

Section 15.249 Radiated Disturbance Limits - Operations within the bands 902-928 MHz at a distance of 3m.

Frequency Range MHz	Quasi-Peak or Average Limits* µV/m	Quasi-Peak or Average Limits* dBµV/m	Peak Limit** µV/m	Peak Limit** dBµV/m
fundamental (902-928)	50,000	94.0	500,000	114.0
harmonics	500	54.0	5000	74.0

* Measurement using Quasi-peak detector for frequencies below 1 GHz and Average Detector above 1 GHz
** Peak Limit 20 dB above Average Limit per Section 15.249(d)

Test Deviations:

None

Test Setup: Only the following ports were tested. See EUT Information for details.

Test Item	Port #	Port Name	EUT Operation Mode	EUT Configuration	Power Interface
A	0	Enclosure	1	1	1

Test 2 - Results: Radiated Disturbance Emissions - 30 to 1000 MHz Electric Field

Test Results Summary:

Test Item	Test Location	Humidity (%)	Temperature (ºC)	Pressure (kPa)	Pass/Fail (P/F)	Date Completed	Comment #
A	A	60	23.0	100.2	P	6/14/00	

The EUT was considered to **Pass** the Requirements.

Comments:

Comment #	Description

Test 2 - Test Equipment Used: Radiated Disturbance Emissions - 30 to 1000 MHz Electric Field

Equipment ID	Description	Manufacturer	Model Number	Last Cal.	Next Cal.
AT0021	Biconical Antenna, 20 to 300 MHz	Chase	VBA6106A	5/17/00	5/31/01
AT0022	Log Periodic Antenna, 200 to 1000 MHz	Chase	UPA6109	5/17/00	5/31/01
ATA034	52ft Cable, N - N	UL	HELIAX	8/28/99	8/31/00
ATA038	33ft Cable, N - N	EMC Technologist	RG-214	7/30/99	7/31/00
HI0034	Temp/Humid. Indicator	Cole - Palmer	99760-00	12/20/99	12/31/00
SAR001	EMI Receiver	Hewlett Packard	8572A	12/14/99	12/31/00
ATA078	1.5m Cable, N - N	Micro-Coax	Low Loss Coaxial	11/2/99	11/30/00

The above equipment has been calibrated and is within the manufacturer's published limit of error. Calibration is traceable to the National Institute of Standards & Technology(NIST) and conforms to ANSI/NCSL Z540-1-1994.

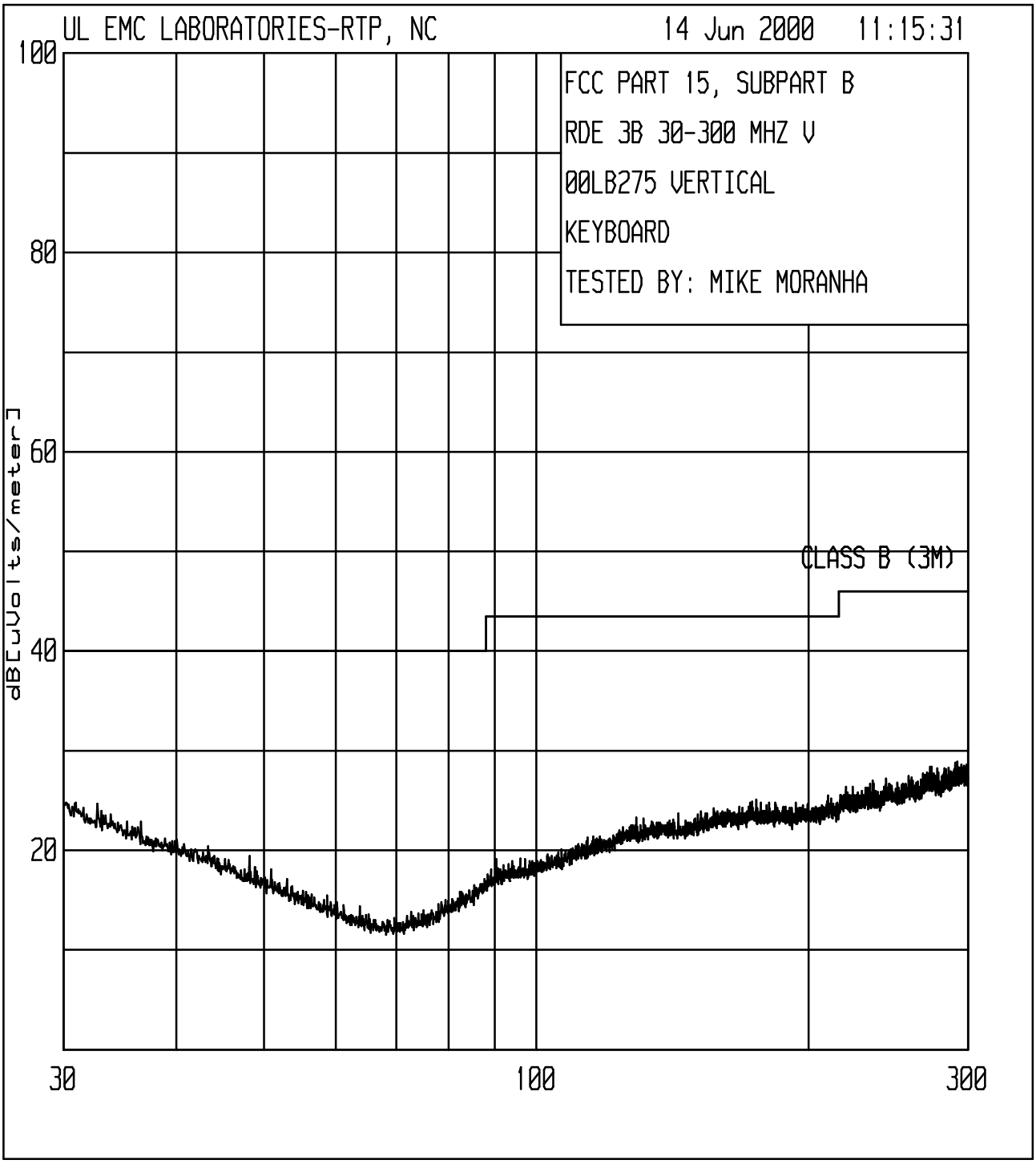
Test 2, Item A - Discrete Data: Radiated Disturbance Emissions - 30 to 1000 MHz Electric Field

Test Item (A-Z)	Detector Type* (P/Q/A)	Antenna Polarity (H/V)	Antenna Distance (m)	Measured Frequency (MHz)	Measured Value (dBµV)	Equipment Correction (dB/m)	Corrected Value (dBµV/m)	Specified Limit** (dBµV/m)	Spec Margin (dB)	See Comment ***(#)
A	P	V	3	916.588	56.6	28.4	85.0	114.0	-29.0	
A	Q	V	3	916.588	54.8	28.4	83.2	94.0	-10.8	
A	P	H	3	916.588	63.3	28.3	91.6	114.0	-22.5	
A	Q	H	3	916.588	63.3	28.3	91.6	94.0	-2.4	

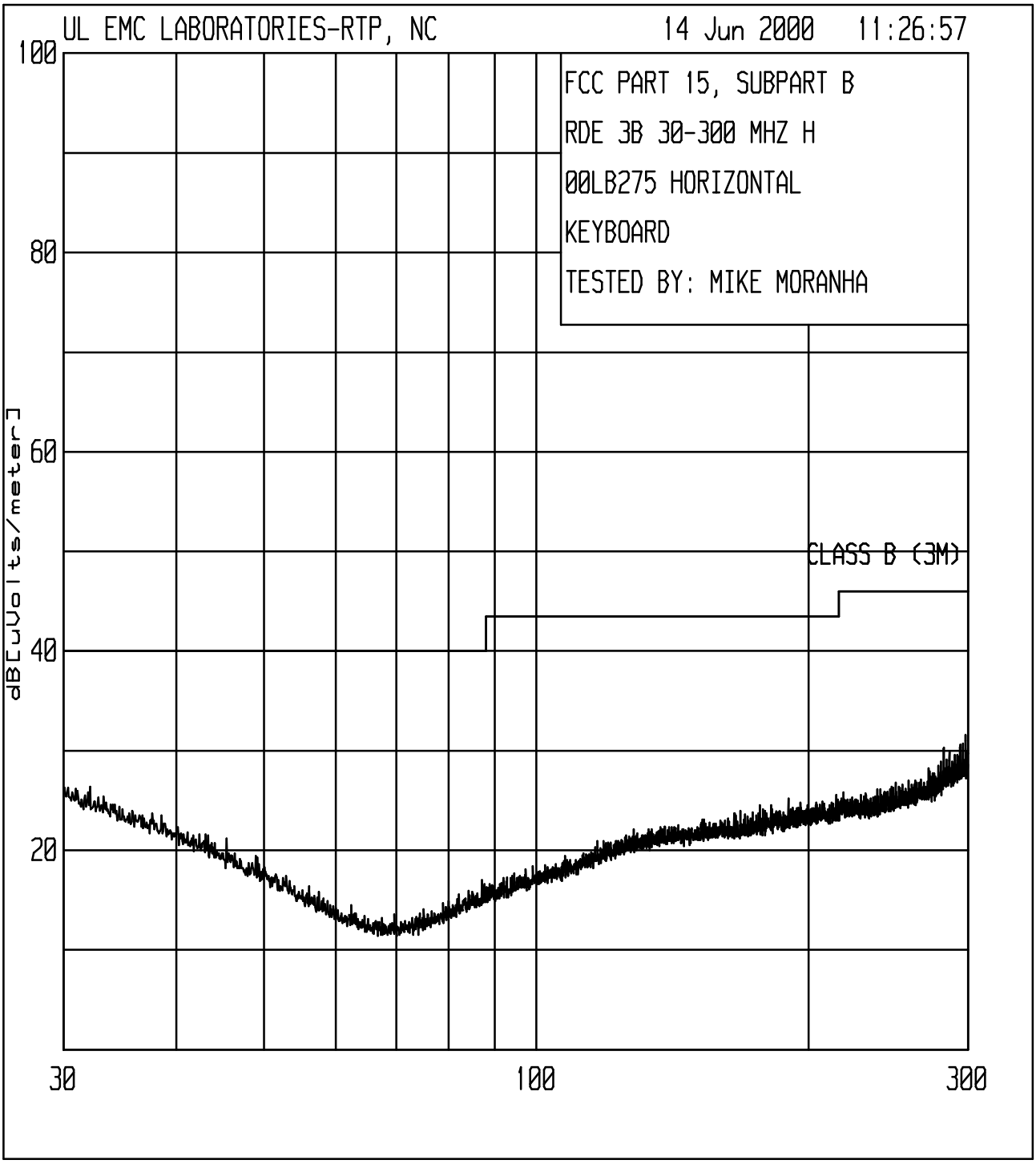
Notes: * P = Peak, Q = Quasi-Peak, A = Average.
** The Specified Limit is for the type measurement indicated. When Peak data is indicated, the tightest limit applicable is indicated.
*** # = See Comment Number Under The Preceeding Test Comments Section.

Sample Calculation: Corrected Value = Measured Value + Equipment Correction
Equipment Correction = Antenna Factor (dB/m) + Cable Loss (dB) - Amplifier Gain (dB, if used)

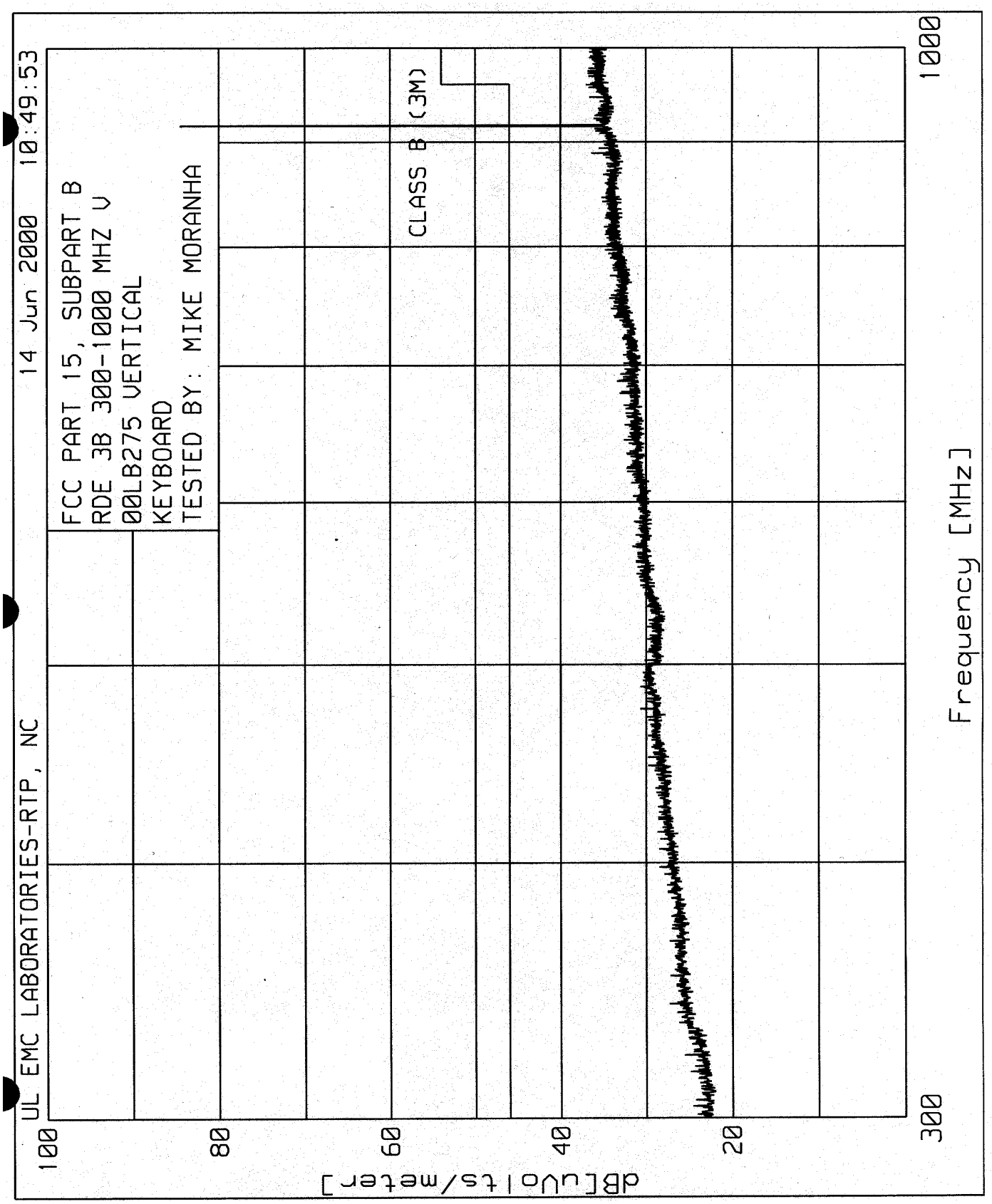
Test 2, Item A - Peak Plot: Radiated Disturbance Emissions - 30 to 1000 MHz Electric Field Vertical



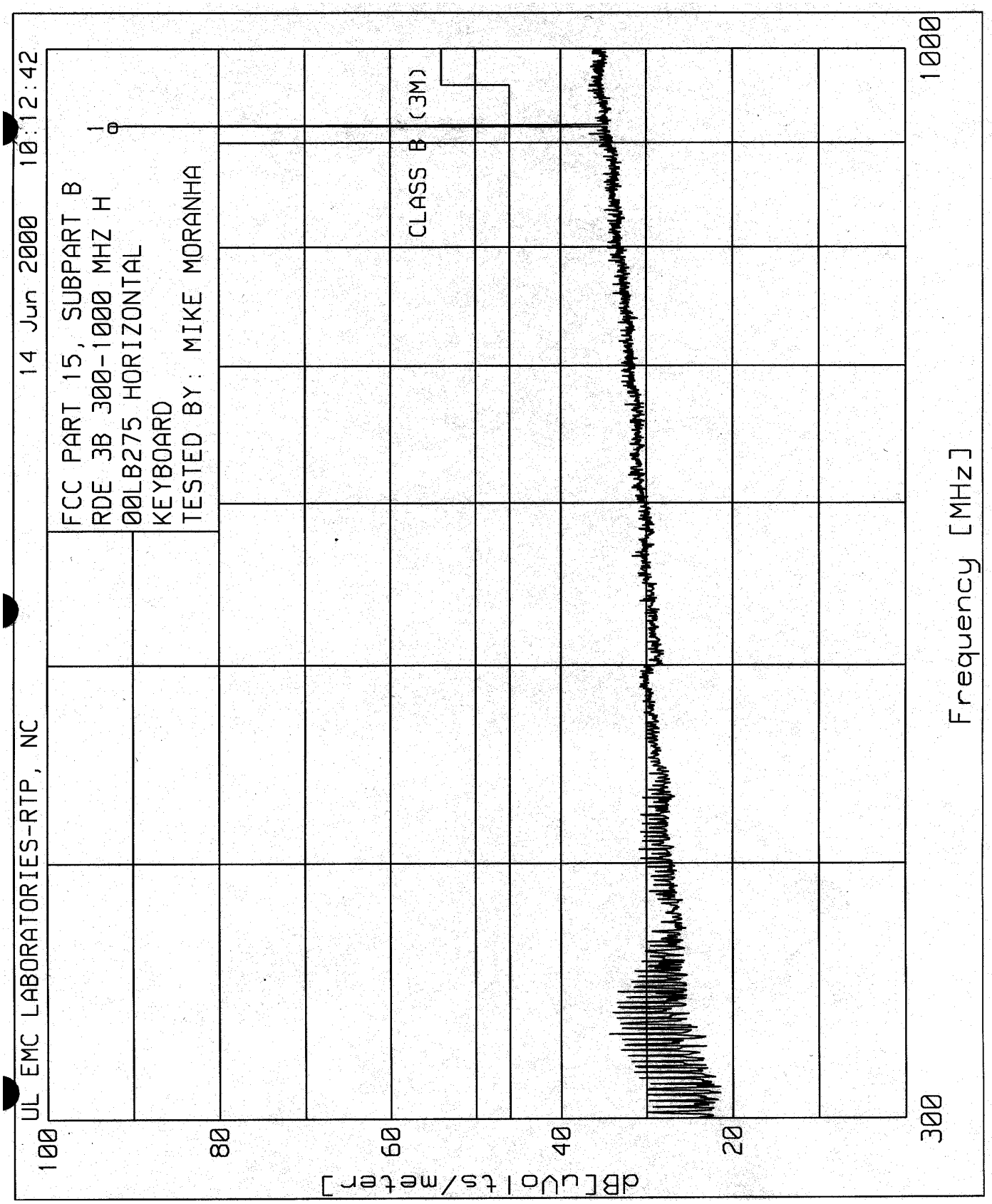
Test 2, Item A - Peak Plot: Radiated Disturbance Emissions - 30 to 300 MHz Electric Field Horizontal



Test 2, Item A - Peak Plot: Radiated Disturbance Emissions - 300 to 1000 MHz Electric Field Vertical



Test 2, Item A - Peak Plot: Radiated Disturbance Emissions - 300 to 1000 MHz Electric Field Horizontal



Test 3: Radiated Disturbance Emissions - 1 to 10 GHz Electric Field

Test Requirement: 47 CFR Part 15, Subpart C

Test Specification: 47 CFR Part 15, Subpart C, Section 15.209

Test Procedure:

The test was performed in accordance with the Test Requirement and Specification and configured as noted in the Test Setup. The EUT was placed inside the anechoic chamber and connected to the proper power supply source. A peak measurement was first made by scanning the entire test frequency range and maximizing the EUT emissions by rotating the EUT and raising the antenna height from 1 to 4 meters above the ground reference plane. Then, a measurement was taken for all peak emissions to verify each were below the Test Limits. In each case, all cables and equipment were adjusted and EUT orientation and antenna height were varied for maximum emissions.

Above 5 Ghz the EUT-to-Antenna distance was reduced to 1 meter. This was done to accomodate the reduced sensitivity of the measurement equipment. The limit was adjusted upward by 9.5 dB using 1/r.

Section 15.209 Radiated Disturbance Limits - General Requirement

Measurement Distance* (m)	Frequency Range (GHz)	Average Limits (µV/m)	Average Limits* (dBµV/m)
3	1 to 40	500	54

* Peak Limit 20 dB above average limit

Section 15.249 Radiated Disturbance Limits - Operations within the bands 902-928 Mhz at a distance of 3m.

Frequency Range MHz	Quasi-Peak or Average Limits* µV/m	Quasi-Peak or Average Limits* dBµV/m	Peak Limit** µV/m	Peak Limit** dBµV/m
fundamental (902-928)	50,000	94.0	500,000	114.0
harmonics	500	54.0	5000	74.0

*Measurement using Quasi-peak detector for frequencies below 1 GHz and Average Detector above 1 GHz.
** Peak Limit 20 dB above Average Limit per Section 15.249(d)

Test Deviations:

None

Test Setup: Only the following ports were tested. See EUT Information for details.

Test Item	Port #	Port Name	EUT Operation Mode	EUT Configuration	Power Interface
A	0	Enclosure	1	1	1

Test 3 - Results: Radiated Disturbance Emissions - 1 to 10 GHz Electric Field

Test Results Summary:

Test Item	Test Location	Humidity (%)	Temperature (ºC)	Pressure (kPa)	Pass/Fail (P/F)	Date Completed	Comment #
A	A	58	22.0	100.0	P	6/14/00	1, 2

The EUT was considered to **Pass** the Requirements. The EUT emissions were found to comply with limits on harmonic emissions in Section 15.249(c) and to the general limits in Section 15.209.

Comments:

Comment #	Description
1	Peak-to-Average Ratio of 17.95 dB (as calculated in Section Test 5 on Page 42) applied to maximum peak measurement to determine average.
2	Measurements above 5 GHz performed at a measurement distance of 1 meter due to measurement sensitivity limitation. Limit was adjusted by 1/r.

Test 3 - Test Equipment Used: Radiated Disturbance Emissions - 1 to 10 GHz Electric Field

Equipment ID	Description	Manufacturer	Model Number	Last Cal.	Next Cal.
AT0020	Horn Antenna, 1 to 18 GHz	Electro-Metrics	EM-6961	11/22/99	11/30/00
ATA034	52ft Cable, N - N	UL	HELIAX	8/28/99	8/31/00
ATA038	33ft Cable, N - N	EMC Technologist	RG-214	7/30/99	7/31/00
HI0034	Temp/Humid. Indicator	Cole - Palmer	99760-00	12/20/99	12/31/00
SAR001	EMI Receiver	Hewlett Packard	8572A	12/14/99	12/31/00
ATA078	1.5m Cable, N - N	Micro-Coax	Low Loss Coaxial	11/2/99	11/30/00

The above equipment has been calibrated and is within the manufacturer's published limit of error. Calibration is traceable to the National Institute of Standards & Technology(NIST) and conforms to ANSI/NCSL Z540-1-1994.

Test 3, Item A - Discrete Data: Radiated Disturbance Emissions - 1 to 10 GHz Electric Field

Test Item (A-Z)	Detector Type* (P/Q/A)	Antenna Polarity (H/V)	Antenna Distance (m)	Measured Frequency (MHz)	Measured Value (dBµV)	Equipment Correction (dB/m)	Corrected Value (dBµV/m)	Specified Limit** (dBµV/m)	Spec Margin (dB)	See Comment ***(#)
A	P	V	3	1833.091	63.4	-3.7	59.7	74.0	-14.3	
A	A	V	3	1833.091	-	-	41.8	54.0	-12.3	
A	P	V	3	2749.515	45.1	2.6	47.7	74.0	-26.3	
A	A	V	3	2749.515	-	-	29.8	54.0	-24.3	
A	P	V	3	3666.320	59.4	5.6	65.0	74.0	-9.0	
A	A	V	3	3666.320	-	-	47.1	54.0	-7.0	
A	P	V	3	4582.845	57.6	7.5	65.1	74.0	-8.9	
A	A	V	3	4582.845	-	-	47.2	54.0	-6.9	
A	P	V	1	5499.494	48.7	10.6	59.3	83.5	-24.2	2
A	A	V	1	5499.494	-	-	41.4	63.5	-22.2	2
A	P	V	1	6415.700	49.2	11.9	61.1	83.5	-22.5	2
A	A	V	1	6415.700	-	-	43.1	63.5	-20.4	2
A	P	V	1	7332.730	50.3	14.7	65.0	83.5	-18.6	2
A	A	V	1	7332.730	-	-	47.0	63.5	-16.5	2
A	P	V	1	8249.321	38.6	16.4	55.0	83.5	-28.5	2
A	A	V	1	8249.321	-	-	37.1	63.5	-26.5	2
A	P	V	1	9165.722	41.3	16.9	58.2	83.5	-25.3	2
A	A	V	1	9165.722	-	-	40.3	63.5	-23.3	2
A	P	H	3	1833.150	62.1	7.9	70.0	74.0	-4.0	
A	A	H	3	1833.150	-	-	52.1	54.0	-2.0	
A	P	H	3	2749.660	42.9	2.5	45.4	74.0	-28.6	
A	A	H	3	2749.660	-	-	27.5	54.0	-26.6	
A	P	H	3	3666.334	64.2	3.6	67.8	74.0	-6.2	
A	A	H	3	3666.334	-	-	49.9	54.0	-4.2	
A	P	H	3	4582.869	50.4	7.7	58.1	74.0	-15.9	
A	A	H	3	4582.869	-	-	40.2	54.0	-13.9	
A	P	H	1	5499.701	59.4	10.2	69.6	83.5	-13.9	2
A	A	H	1	5499.701	-	-	51.7	63.5	-11.9	2
A	P	H	1	6416.188	50.0	11.9	61.9	83.5	-21.7	2
A	A	H	1	6416.188	-	-	43.9	63.5	-19.6	2

Notes: * P = Peak, Q = Quasi-Peak, A = Average.
** The Specified Limit is for the type measurement indicated. When Peak data is indicated, the tightest limit applicable is indicated.
*** # = See Comment Number Under This Section's Comments on Page 27.

Sample Calculation: Corrected Value = Measured Value + Equipment Correction
Equipment Correction = Antenna Factor (dB/m) + Cable Loss (dB) - Amplifier Gain (dB, if used)

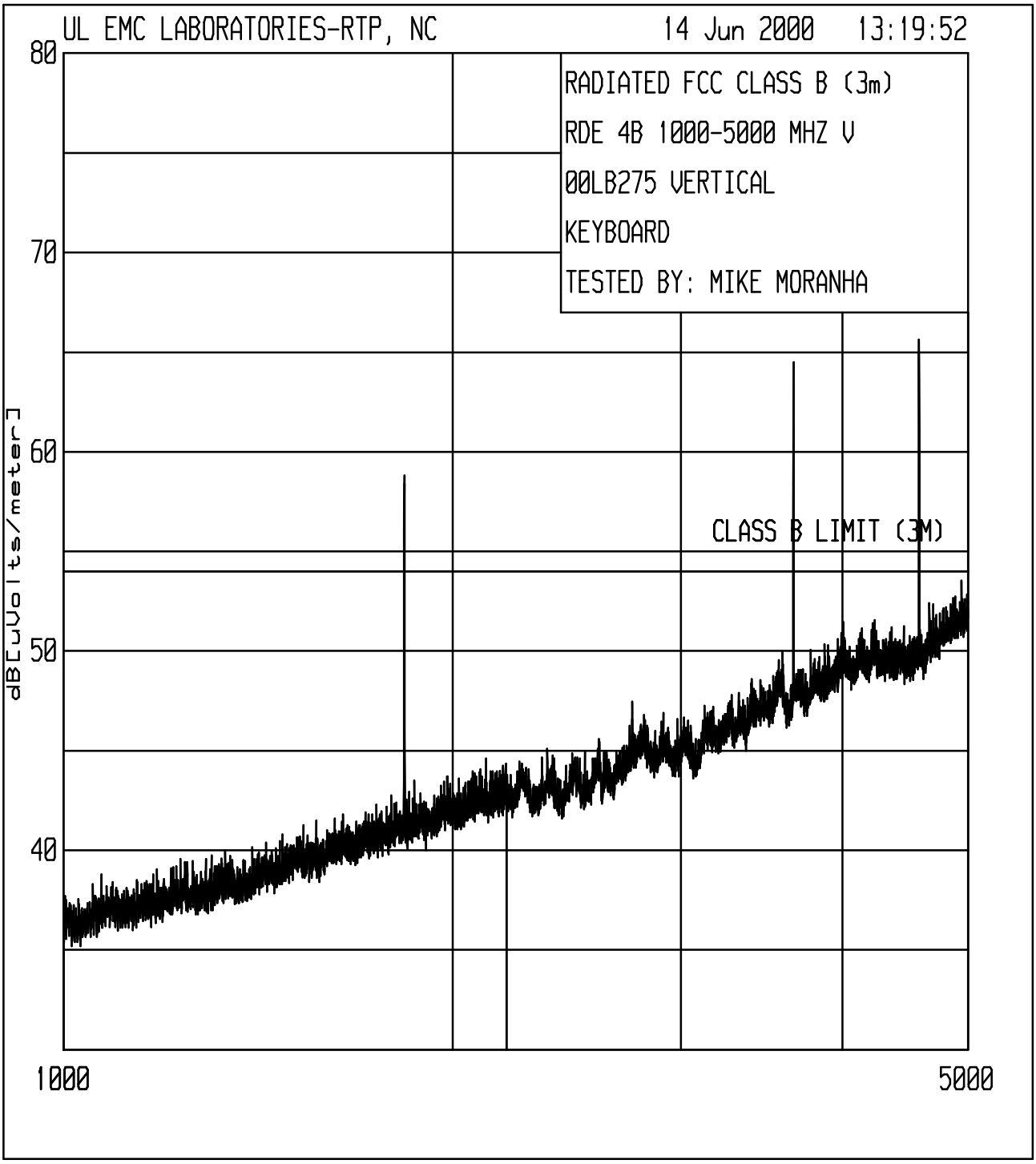
Test 3, Item A - Discrete Data: Radiated Disturbance Emissions - 1 to 10 GHz Electric Field

Test Item (A-Z)	Detector Type* (P/Q/A)	Antenna Polarity (H/V)	Antenna Distance (m)	Measured Frequency (MHz)	Measured Value (dBµV)	Equipment Correction (dB/m)	Corrected Value (dBµV/m)	Specified Limit** (dBµV/m)	Spec Margin (dB)	See Comment ***(#)
A	P	H	1	7332.580	52.0	15.1	67.1	83.5	-16.5	2
A	A	H	1	7332.580	-	-	49.1	63.5	-14.4	2
A	P	H	1	8249.303	40.5	16.4	56.9	83.5	-26.6	2
A	A	H	1	8249.303	-	-	39.0	63.5	-24.6	2
A	P	H	1	9165.696	45.2	17.0	62.2	83.5	-21.3	2
A	A	H	1	9165.696	-	-	44.3	63.5	-19.3	2

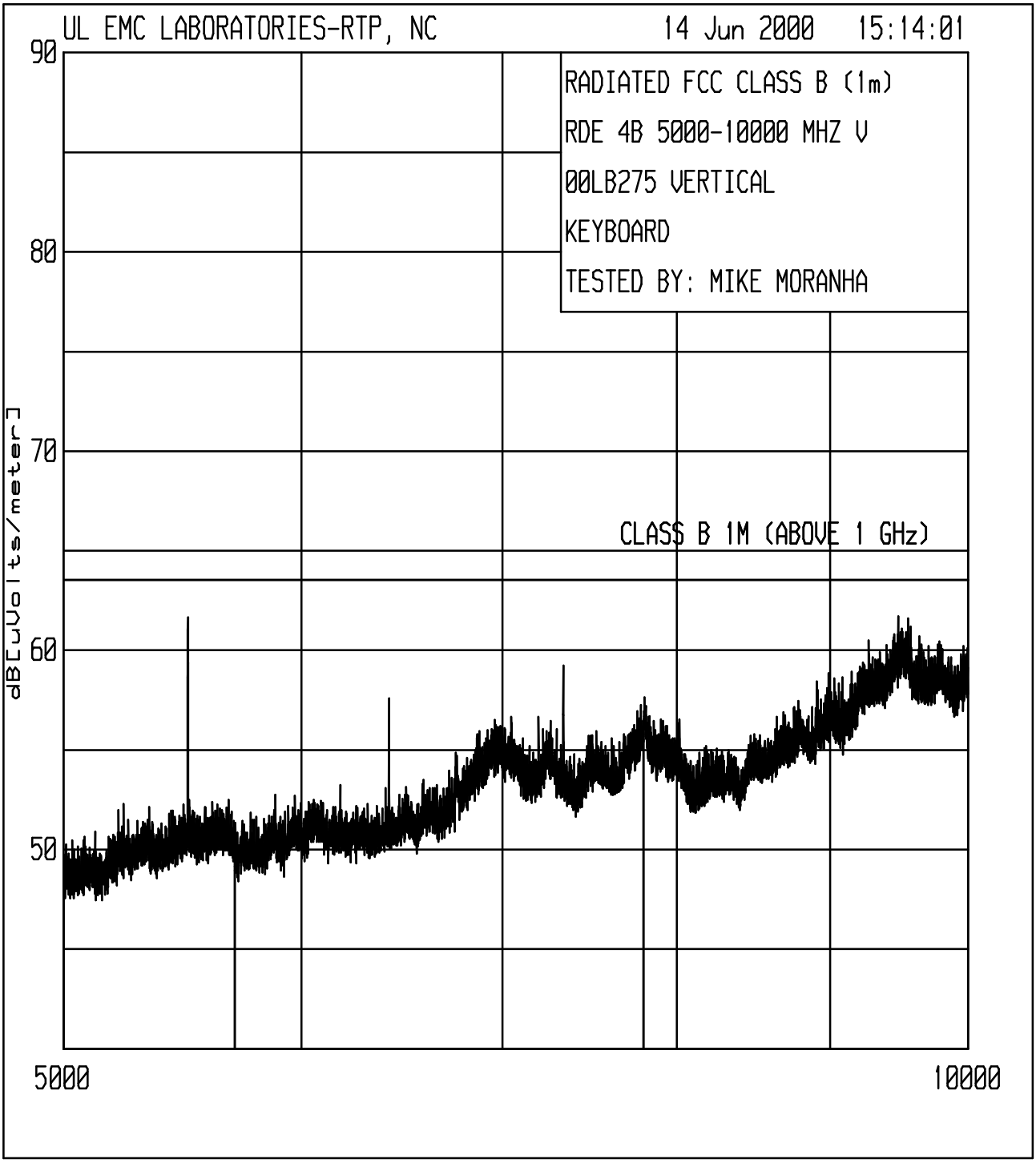
Notes: * P = Peak, Q = Quasi-Peak, A = Average.
** The Specified Limit is for the type measurement indicated. When Peak data is indicated, the tightest limit applicable is indicated.
*** # = See Comment Number Under The Preceeding Test Comments Section.

Sample Calculation: Corrected Value = Measured Value + Equipment Correction
Equipment Correction = Antenna Factor (dB/m) + Cable Loss (dB) - Amplifier Gain (dB, if used)

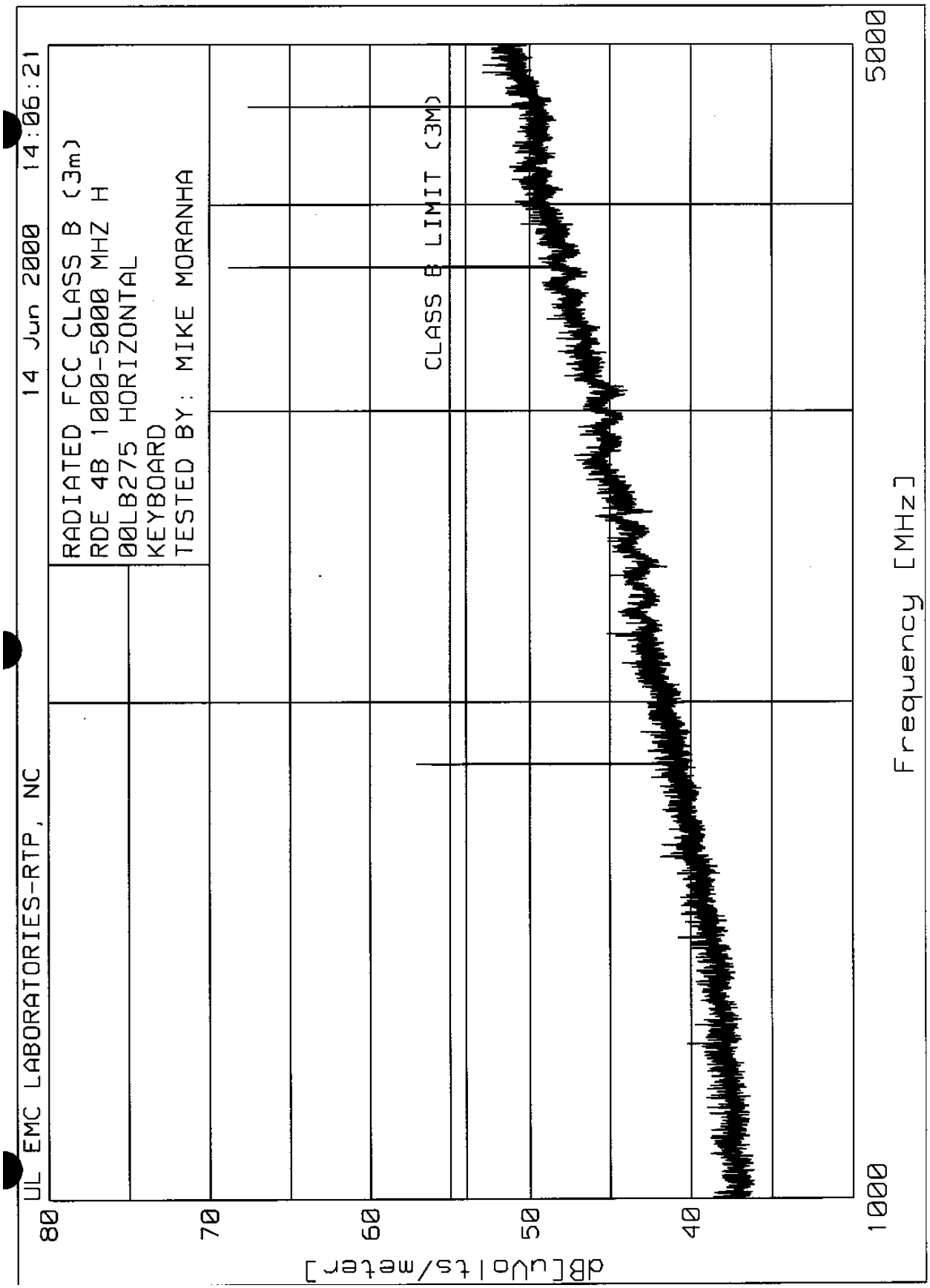
Test 3, Item A - Peak Plot: Radiated Disturbance Emissions - 1 to 5 GHz Electric Field Vertical



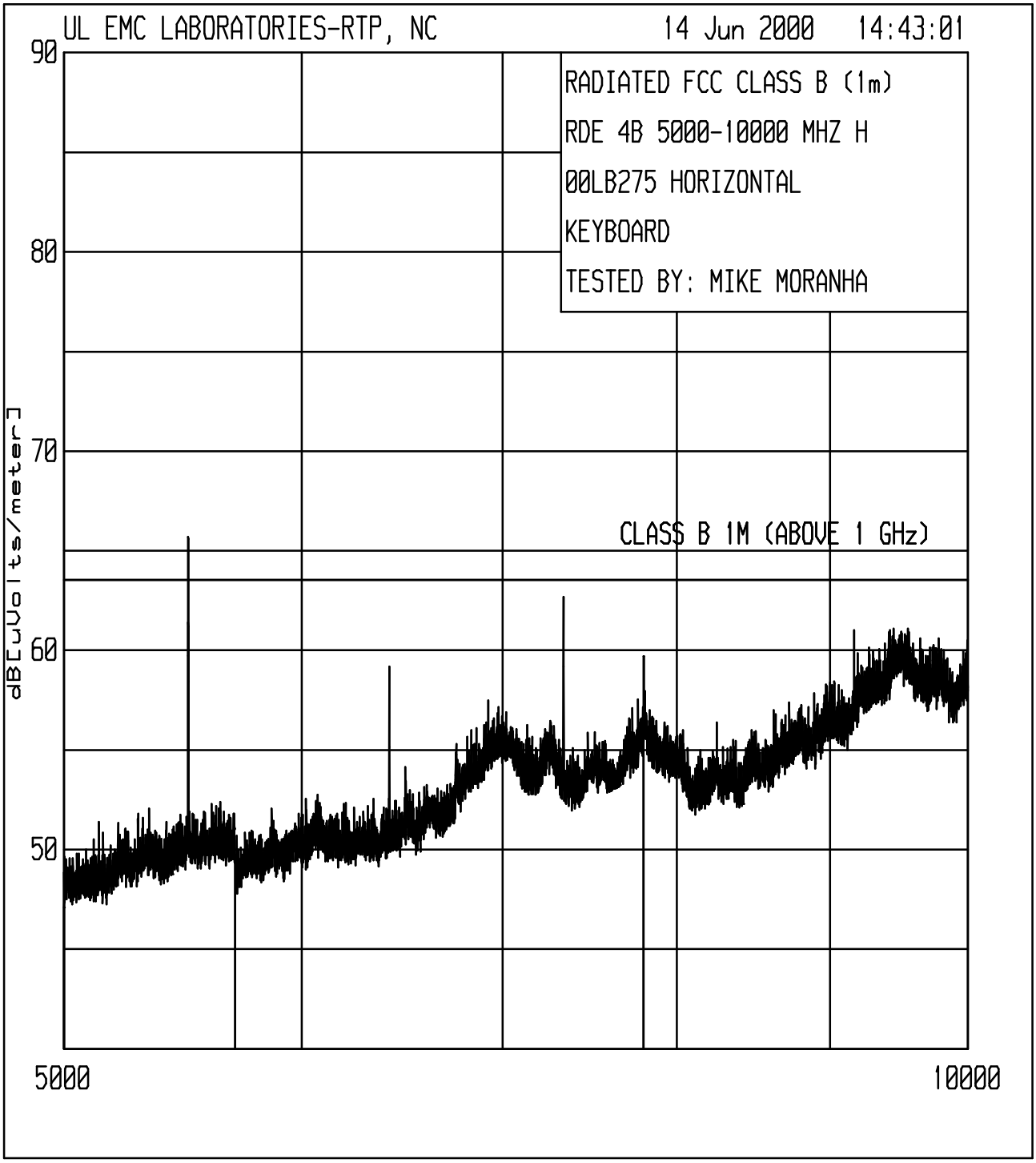
Test 3, Item A - Peak Plot: Radiated Disturbance Emissions - 5 to 10 GHz Electric Field Vertical



Test 3, Item A - Peak Plot: Radiated Disturbance Emissions - 1 to 5 GHz Electric Field Horizontal



Test 3, Item A - Peak Plot: Radiated Disturbance Emissions - 5 to 10 GHz Electric Field Horizontal



Test 4: Radiated Disturbance Emissions - Occupied Bandwidth

Test Requirement: 47 CFR Part 15, Subpart C

Test Specification: 47 CFR Part 15, Subpart C Section 15.249

Test Procedure:

All testing was performed in UL's 10 meter semi-anechoic chamber. The chamber meets the FCC's site attenuation criteria for use as an alternative measurement site. The EUT was tested per ANSI C63.4:1992 test method placed on a non-conductive 1m x 1.5m table 80 cm above the ground plane. The receive antenna used was a log-periodic antenna mounted on an antenna mast. The turntable was rotated from 0° to 360° to determine the worst-case emissions angle for the transmit frequency. The antenna mast was raised and lowered between 1 and 4 meters above the ground plane to determine the worst-case height.

The spectrum analyzer Resolution Bandwidth and Video Bandwidth were set to 10 kHz for the measurement. A plot of the spectrum analyzer display screen is produced with marker points displaying the center frequency and the left and right side points that are 20 dB below the field strength at the center frequency.

Occupied Bandwidth Limit - Manually Operated Transmitter Section 15.249

Transmit Frequency (MHz)	Bandwith Limit* (MHz)
902 to 928	26 MHz

* No designated channels within 902-928 Mhz band are specified in 15.249. Allowable Bandwidth is considered to be the entire band. Signal is to be further verified to meet general limits of Section 15.209 outside 902-928 Mhz band as required by Section 15.249(c)

Test Deviations:

Occupied Bandwidth

Test Setup: Only the following ports were tested. See EUT Information for details.

Test Item	Port #	Port Name	EUT Operation Mode	EUT Configuration	Power Interface
A	0	Enclosure	1	1	1

Test 4 - Results: Radiated Disturbance Emissions - Occupied Bandwidth

Test Results Summary:

Test Item	Test Location	Humidity (%)	Temperature (ºC)	Pressure (kPa)	Pass/Fail (P/F)	Date Completed	Comment #
A	A	51	22.5	100.1	P	6/14/00	

The EUT was considered to **Pass** the Requirements.

Comments:

Comment #	Description
1	For measurement of occupied bandwidth EUT is transmitting a repeating stream of bytes that is representative of maximum machine speed.

Test 4 - Test Equipment Used: Radiated Disturbance Emissions - Occupied Bandwidth

Equipment ID	Description	Manufacturer	Model Number	Last Cal.	Next Cal.
AT0022	Log Periodic Antenna, 200 to 1000 MHz	Chase	UPA6109	5/17/00	5/31/01
ATA034	52ft Cable, N - N	UL	HELIAX	8/28/99	8/31/00
ATA038	33ft Cable, N - N	EMC Technologist	RG-214	7/30/99	7/31/00
HI0034	Temp/Humid. Indicator	Cole - Palmer	99760-00	12/20/99	12/31/00
SAR001	EMI Receiver	Hewlett Packard	8572A	12/14/99	12/31/00
ATA078	1.5m Cable, N - N	Micro-Coax	Low Loss Coaxial	11/2/99	11/30/00

The above equipment has been calibrated and is within the manufacturer's published limit of error. Calibration is traceable to the National Institute of Standards & Technology(NIST) and conforms to ANSI/NCSL Z540-1-1994.

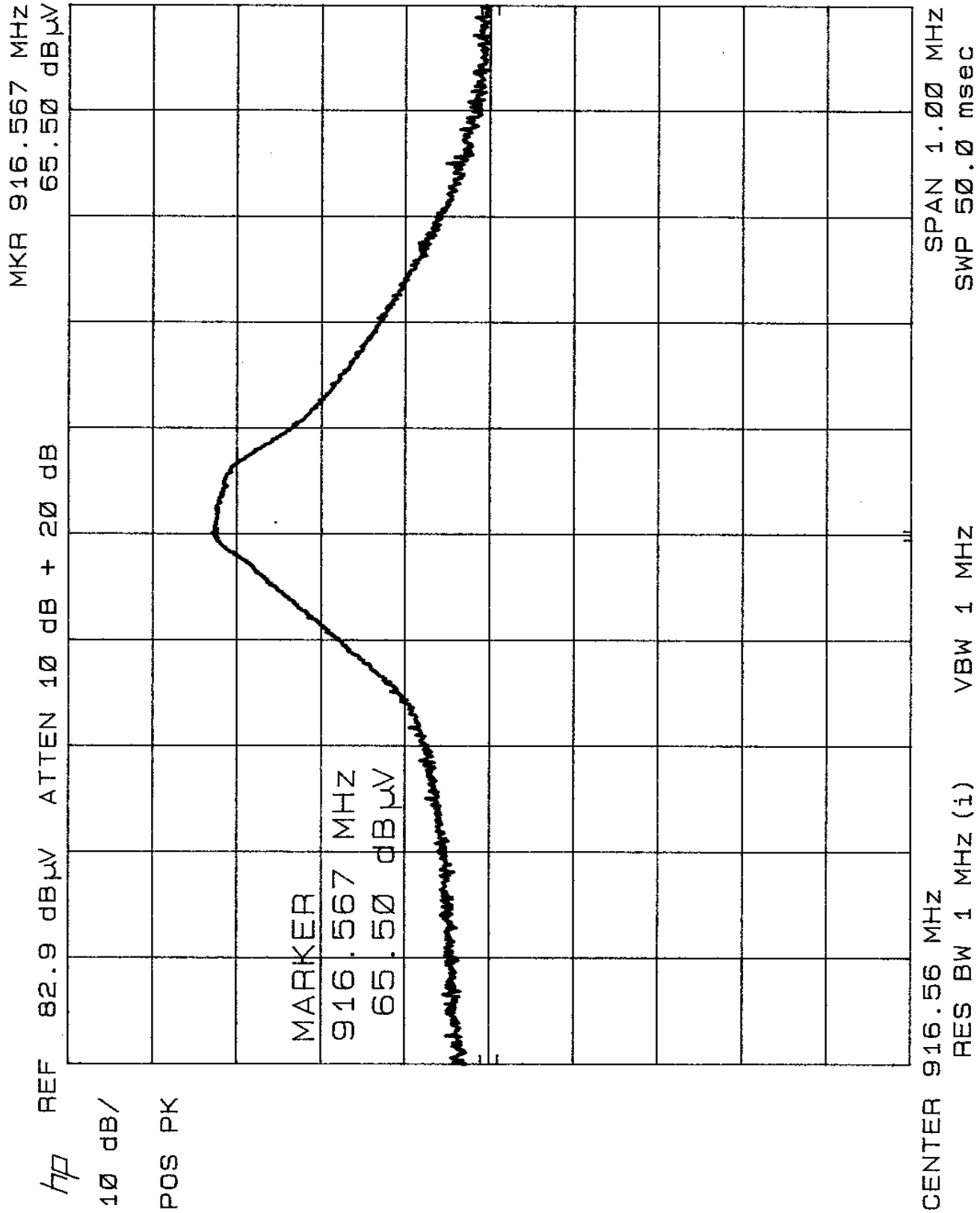
Test 4, Item A - Discrete Data: Radiated Disturbance Emissions - Occupied Bandwidth

Center Frequency (MHz)	20 dB Bandwidth (MHz)	Bandwidth Limit (MHz)
916.567	0.341	26.0

*Transmission was verified not to exceed general limits outside left band edge (at 902 Mhz) and right band edge (at 928 Mhz) as required in Section 15.249.

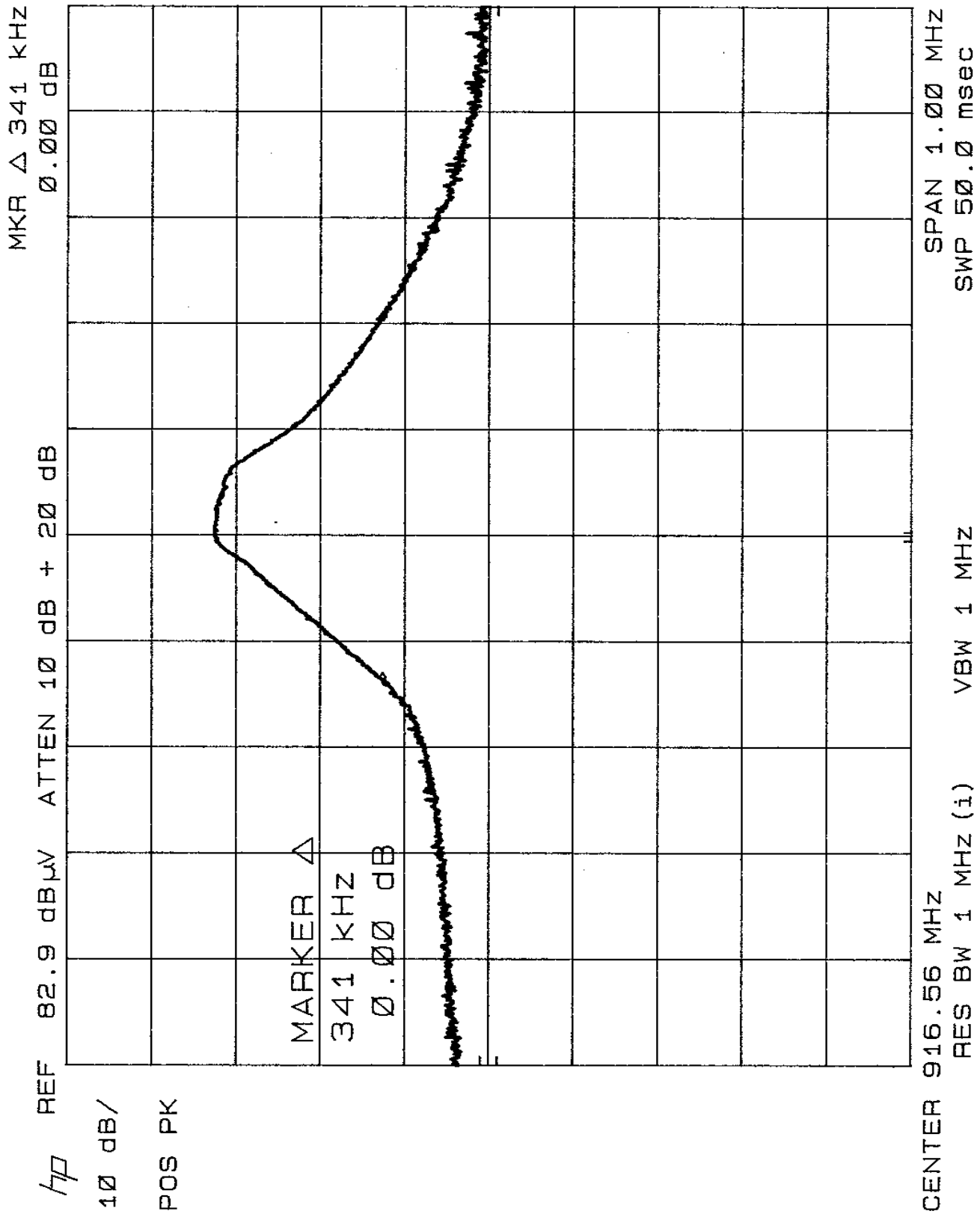
Test 4, Item A - Center Frequency:

Radiated Disturbance Emissions - 30 to 1000 MHz Electric Field



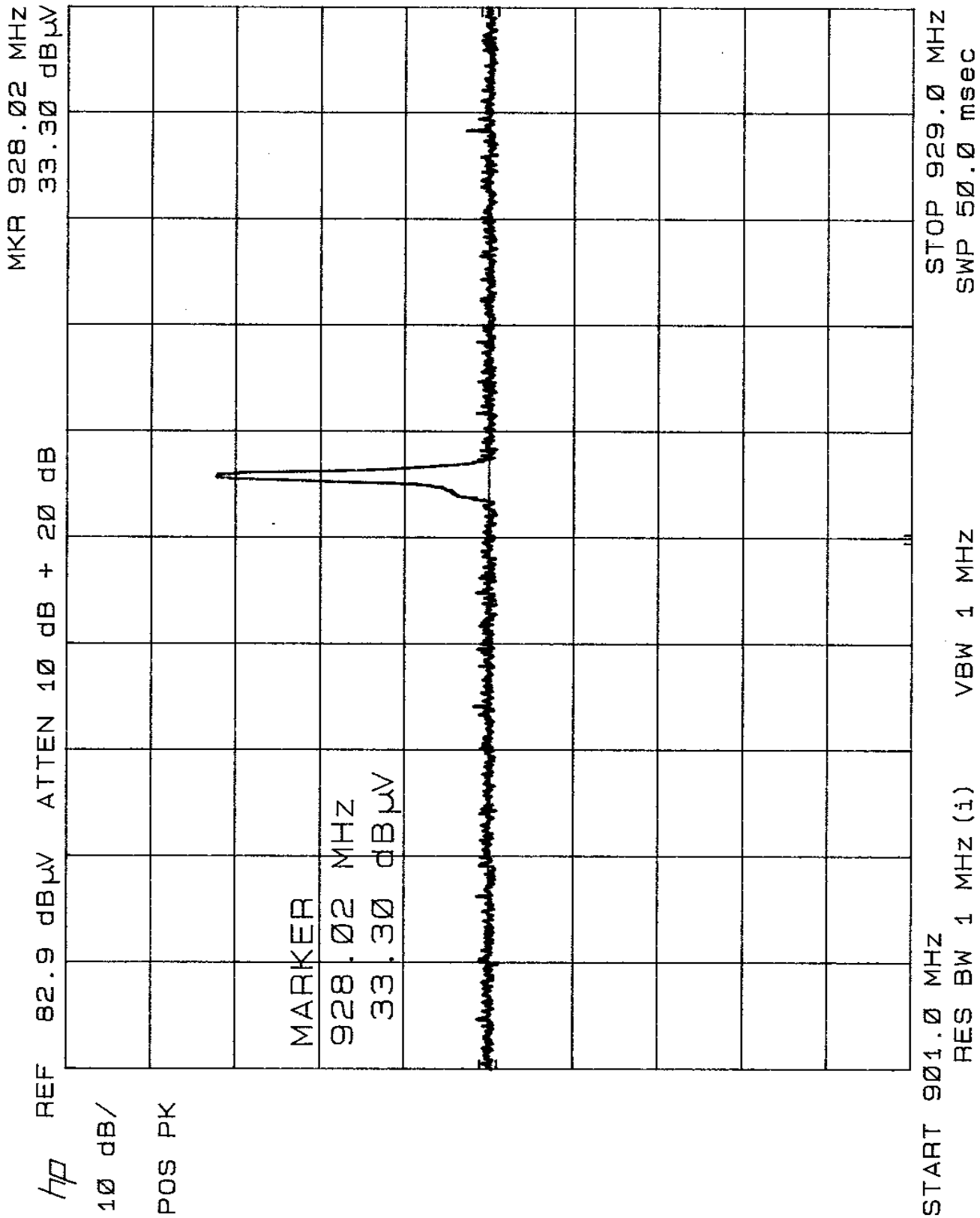
Test 4, Item A - Occupied Bandwidth:

Radiated Disturbance Emissions - 30 to 1000 MHz Electric Field



Test 4, Item A - Complete 902-928 Band:

Radiated Disturbance Emissions - 30 to 1000 MHz Electric Field



Test 5: Radiated Disturbance Emissions - Peak-to-Average Ratio

Test Requirement: 47 CFR Part 15, Subpart C

Test Specification: 47 CFR Part 15, Subpart C, Section 15.249

Test Procedure:

The test was performed in accordance with the Test Requirement and Specification and configured as noted in the Test Setup. The EUT was placed inside the anechoic chamber and connected to the proper power supply source.

Test Details:

Center the transmit frequency on the spectrum analyzer display and change the frequency span to 0 Hz. Place the spectrum analyzer in linear mode and move the peak emission near the top of the screen. Capture two screen images that demonstrate:

(1) The total period between bursts (burst 1 start to burst 2 start). Use marker delta to display the elapsed time on the plot.

(2) An expanded view of the bursts ON period. Use marker delta to display the elapsed time of the bursts ON duration.
Use the marker to record the on time of each burst within the pulse and write on the data sheet.

Duty cycle = sum of pulse durations / total cycle-to-cycle period

Peak to Average Ratio (in dB) = 20*log(duty cycle). This number will be used to calculate average values from peak measurements per FCC method (Heirmann, TCB Training Seminar - Feb, 2000).

Test Deviations:

Peak-to-Average Ratio

Test Setup: Only the following ports were tested. See EUT Information for details.

Test Item	Port #	Port Name	EUT Operation Mode	EUT Configuration	Power Interface
A	0	Enclosure	1	1	1

Test 5 - Results: Radiated Disturbance Emissions - Peak-to-Average Ratio

Test Results Summary:

Test Item	Test Location	Humidity (%)	Temperature (ºC)	Pressure (kPa)	Pass/Fail (P/F)	Date Completed	Comment #
A	A	51	22.5	100.1	Not Applicable	6/14/00	1

Comments:

Comment #	Description
1	Peak-to-Average ratio was determined by measuring on/off duty cycle at the fundamental frequency. This ratio, expressed in dB offset from peak emission, is applied to peak measurements wherever an average detector is specified. In this case average detector is specified for frequencies greater than 1 Ghz, therefore peak-to-average ratio is applied to harmonics but not the fundamental frequency itself.

Test 5 - Test Equipment Used: Radiated Disturbance Emissions - Peak-to-Average Ratio

Equipment ID	Description	Manufacturer	Model Number	Last Cal.	Next Cal.
AT0022	Log Periodic Antenna, 200 to 1000 MHz	Chase	UPA6109	5/17/00	5/31/01
ATA034	52ft Cable, N - N	UL	HELIAX	8/28/99	8/31/00
ATA038	33ft Cable, N - N	EMC Technologist	RG-214	7/30/99	7/31/00
HI0034	Temp/Humid. Indicator	Cole - Palmer	99760-00	12/20/99	12/31/00
SAR001	EMI Receiver	Hewlett Packard	8572A	12/14/99	12/31/00
ATA078	1.5m Cable, N - N	Micro-Coax	Low Loss Coaxial	11/2/99	11/30/00

The above equipment has been calibrated and is within the manufacturer's published limit of error. Calibration is traceable to the National Institute of Standards & Technology(NIST) and conforms to ANSI/NCSL Z540-1-1994.

Test 5, Item A - Calculation: Radiated Disturbance Emissions - Peak-to-Average Ratio

The total period of the transmission from beginning of one burst to the beginning of the next burst was measured to be 24.25 ms. The pulse train produced will vary according to the number and address code of keys depressed. The theoretical worst-case involves depressing six keys simulateously and is calculated below:

Worst-Case Pulse

Bytes (description:	Maximum "ON" bits per byte	Total "ON" bits
4 (sync bytes)	5	20
1 (address bytes)	3	3
1 (length byte)	3	3
6 (worst-case data)	5	30
1 (CRC byte)	8	+ 8
Maximum "ON" bits per burst		64

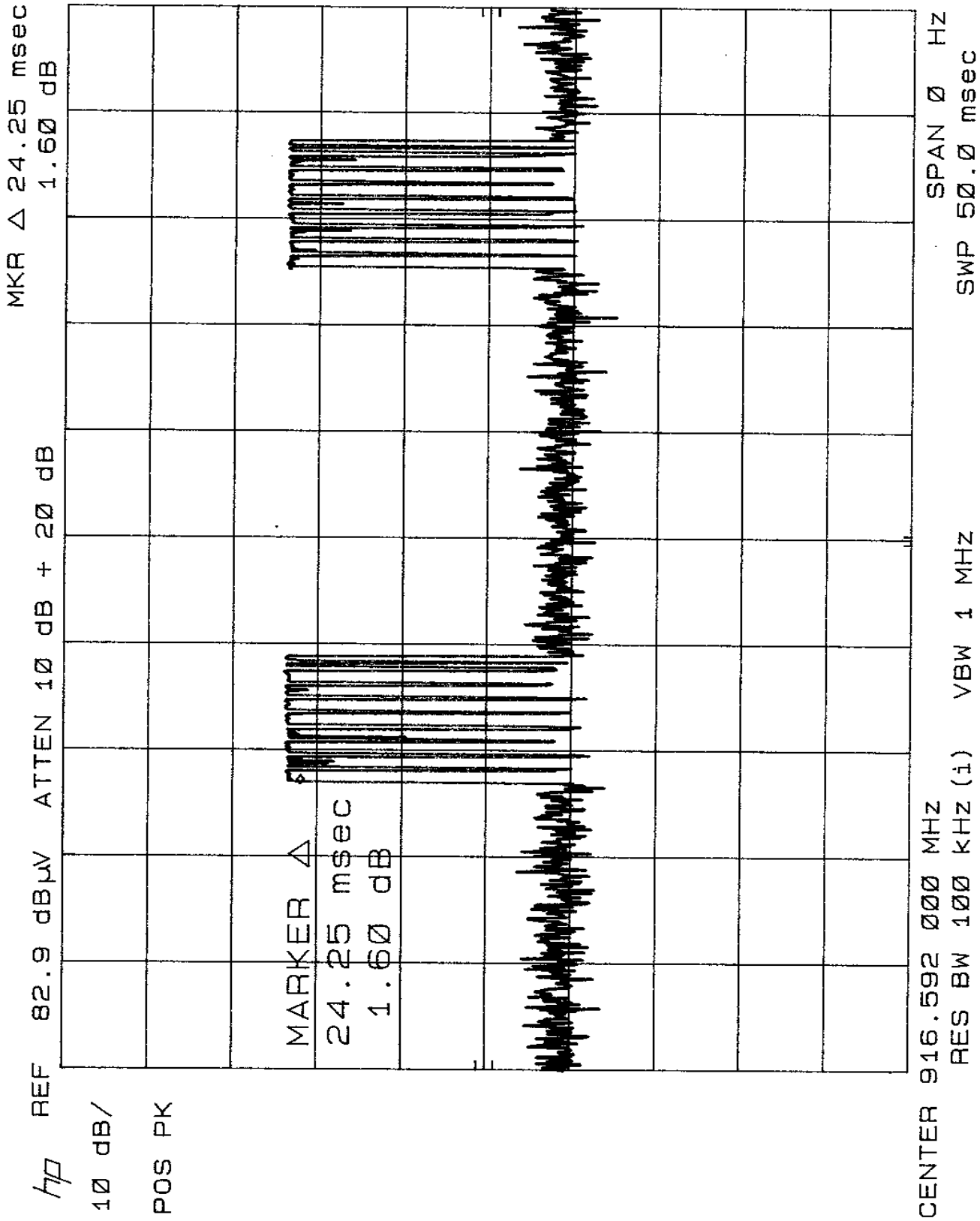
Measured time per "ON" bit = 48 µs

Maximum "ON" time per burst = 64 bits x 0.048 ms = 3.072 ms

Duty cycle = 3.072 ms / 24.25 ms = **12.66%** = 20*LOG(0.1266) dB = **17.95 dB**

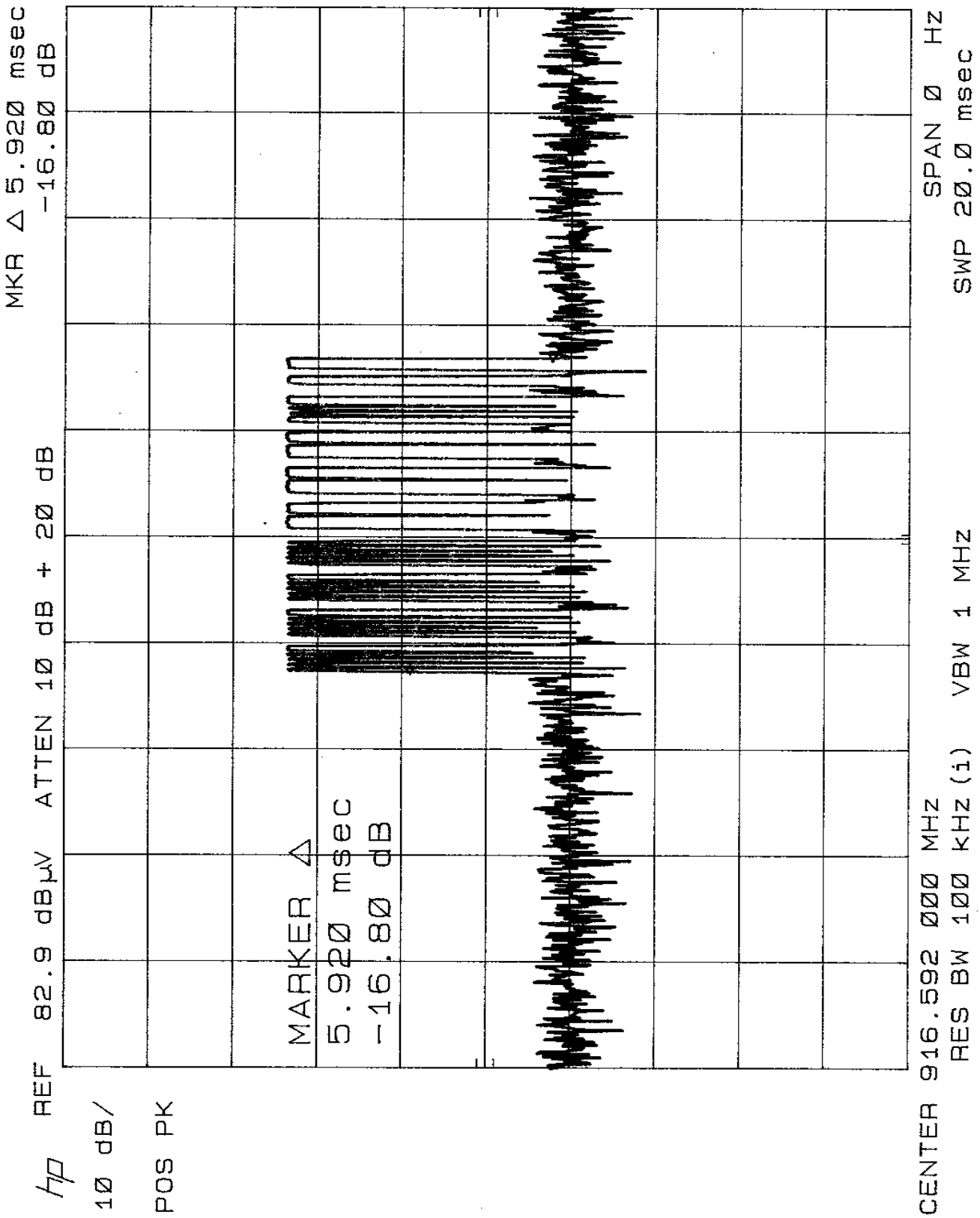
Test 5, Item A - Burst Period:

Radiated Disturbance Emissions - Burst Period



Test 5, Item A - Typical Burst (Mathematical Worst-Case Burst used for Calculation):

Radiated Disturbance Emissions - Typical Burst



Test 6: Radiated Disturbance Emissions - Restricted Bands of Operation

Test Requirement: 47 CFR Part 15, Subpart C

Test Specification: 47 CFR Part 15, Subpart C, Section 15.205

Test Procedure:

The EUT is verified to produce only spurious emissions in the bands listed below. Where spurious emissions exist they must comply with the general limits from 47 CFR Part 15, Section 15.209.

Test Details:

Results from measurements are examined to ensure that no spurious emission in a restricted band (below) exceeds the limits in Section 15.209. The restricted bands from Section 15.205 are:

MHz	MHz	MHz	GHz
0.090 - 0.110	16.42 - 16.423	399.9 - 410	4.5 - 5.15
[1]0.495 - 0.505	16.69475 - 16.69525	608 - 614	5.35 - 5.46
2.1735 - 2.1905	16.80425 - 16.80475	960 - 1240	7.25 - 7.75
4.125 - 4.128	25.5 - 25.67	1300 - 1427	8.025 - 8.5
4.17725 - 4.17775	37.5 - 38.25	1435 - 1626.5	9.0 - 9.2
4.20725 - 4.20775	73 - 74.6	1645.5 - 1646.5	9.3 - 9.5
6.215 - 6.218	74.8 - 75.2	1660 - 1710	10.6 - 12.7
6.26775 - 6.26825	108 - 121.94	1718.8 - 1722.2	13.25 - 13.4
6.31175 - 6.31225	123 - 138	2200 - 2300	14.47 - 14.5
8.291 - 8.294	149.9 - 150.05	2310 - 2390	15.35 - 16.2
8.362 - 8.366	156.52475 -	2483.5 - 2500	17.7 - 21.4
8.37625 - 8.38675	156.52525	2655 - 2900	22.01 - 23.12
8.41425 - 8.41475	156.7 - 156.9	3260 - 3267	23.6 - 24.0
12.29 - 12.293	162.0125 - 167.17	3332 - 3339	31.2 - 31.8
12.51975 - 12.52025	167.72 - 173.2	3345.8 - 3358	36.43 - 36.5
12.57675 - 12.57725	240 - 285	3600 - 4400	([2])
13.36 - 13.41	322 - 335.4		

Test Results:

All Spurious emissions, including harmonics falling within restricted bands at 2749 MHz, 3666 MHz, 4582 MHz, 5499 MHz, 7332 MHz, 8249 MHz, and 9165 MHz, were observed to meet the general limits of 15.209.

Accreditation Certificates:

National Institute of Standards and Technology — NVLAP® — National Voluntary Laboratory Accreditation Program

ISO/IEC GUIDE 25:1990
ISO 9002:1987

Scope of Accreditation

Page: 1 of 2

ELECTROMAGNETIC COMPATIBILITY AND TELECOMMUNICATIONS — **NVLAP LAB CODE 200246-0**

UNDERWRITERS LABORATORIES, INC.
12 Laboratory Drive
Research Triangle Park, NC 27709
Mr. Rick A. Titus
Phone: 847-272-8800 x43281 Fax: 847-509-6321
E-Mail: Rick.A.Titus@us.ul.com
URL: http://www.ul.com

NVLAP Code	*Designation / Description*
Emissions Test Methods:	
12/CIS22	IEC/CISPR 22:1993: Limits and methods of measurement of radio disturbance characteristics of information technology equipment
12/CIS22a	IEC/CISPR 22:1993: Limits and methods of measurement of radio disturbance characteristics of information technology equipment, Amendment 1:1995, and Amendment 2:1996.
12/CIS22b	CNS 13438:1997: Limits and Methods of Measurement of Radio Interference Characteristics of Information Technology Equipment
12/F01	FCC Method - 47 CFR Part 15 - Digital Devices
12/F01a	Conducted Emissions, Power Lines, 450 KHz to 30 MHz
12/F01b	Radiated Emissions

June 30, 2001 — *Effective through*

David F. Alderman — *For the National Institute of Standards and Technology*

NVLAP-01S (11-95)

National Institute of Standards and Technology — NVLAP® — National Voluntary Laboratory Accreditation Program

ISO/IEC GUIDE 25:1990
ISO 9002:1987

Scope of Accreditation

Page: 2 of 2

ELECTROMAGNETIC COMPATIBILITY AND TELECOMMUNICATIONS — **NVLAP LAB CODE 200246-0**

UNDERWRITERS LABORATORIES, INC.

NVLAP Code	*Designation / Description*
12/T51	AS/NZS 3548: Electromagnetic Interference - Limits and Methods of Measurement of Information Technology Equipment
Safety Test Methods:	
12/T41	ACA TS-001: Safety Requirements for Customer Equipment
12/T50	AS/NZS 3260: Safety of Information Technology Equipment Including Electrical Business Equipment

June 30, 2001 — *Effective through*

David F. Alderman — *For the National Institute of Standards and Technology*

NVLAP-01S (11-95)

Measurement Uncertainty Statement

The limits and test levels have been set taking into account the measurement uncertainty contributions from the test equipment and facilities which meet the accuracy limits stated in the relevant basic standard. In the case of emissions tests, the measured value shall be compared directly with the limits. If the measured value is equal to or less than the limit the product sample is deemed to pass the test. (REF: prEN 50222:1997). The measured value does not need to be adjusted by the measurement uncertainty to determine compliance.

Example of Measurement of field strength between 30 dBµV/m and 60 dBµV/m over the frequency range 30 MHz to 300 MHz (biconical) In UL Anechoic Chamber @ 10m

Expanded Std Uncertainty . . . . . 3.71 dB

Example of Measurement of field strength between 30 dBµV/m and 60 dBµV/m over the frequency range 200 MHz to 1000 MHz (log-periodic) In UL Anechoic Chamber @ 10m

Expanded Std Uncertainty . . . . . 3.19 dB

Example of Measurement of conducted voltage, signal strength between 30 dBµV/m and 50 dBµV/m over the frequency range 150 kHz to 30 MHz

Expanded Std Uncertainty . . . . . 2.16 dB